Ray W. Walker

Proceedings

CHEATGRASS SYMPOSIUM

July 27 - 30, 1965

Cheatgrass

Sponsored by
United States Department of the Interior
Bureau of Land Management
Oregon-Washington State Office

PREFACE

This report updates the latest research in the fields of Cheatgrass and Medusahead rye grass. Sixteen outstanding research specialists accepted the invitation from the Bureau of Land Management to join at Vale, Oregon and for three days reported to attendees on their work. Here in the few minutes allotted each man were presented the condensation of several years of study. The following pages are a further condensation of these efforts.

The Oregon State Office of the Bureau of Land Management wishes to acknowledge the generosity of each of these men who took the time, without emolument, to journey to Vale from many distant places, and for the work devoted to their excellent presentations. The Bureau of Land Management is most appreciative.

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Attendees

Edwin B. Abbott	Malheur N.F.	John Day, Oregon
Myron V. Adams	BLM	Ukiah, California
L. Paul Applegate	BLM	Winnemucca, Nevada
James H. Bachman	BLM	Vale, Oregon
Chad A. Bacon	BLM	Vale, Oregon
George W. Bain	Extension Service	Ontario, Oregon
Lawrence H. Bardsley	BLM	Shoshone, Idaho
R. Gordon Bentley	BLM	St. George, Utah
Dean Bibles	BLM	Burley, Idaho
Edward C. Booker	BLM	Boise, Idaho
Thomas A. Brannon	BLM	Sacramento, California
Max W. Bridge	BLM	Denver, Colorado
Tom Bunch	Ext. OSU	Corvallis, Oregon
Martin W. Buzan	BLM	Reno, Nevada
Dwight C. Conley	BLM	Prineville, Oregon
Howard R. DeLano	BLM	Portland, Oregon
Don Dimock	BLM	Sacramento, California
Raymond A. Evans	ARS, Crops Res. U. of N.	Reno, Nevada
Delbert Fallon	BLM	Boise, Idaho
George Farris	BLM	Susanville, California
Maynard Fosberg	Univ. of Idaho	Moscow, Idaho
Ethan W. Freeman	BLM	Vale, Oregon
Glen D. Fulcher	BLM	Washington, D.C.
George A. Garrison	PNW Exp. Sta. USFS	LaGrande, Oregon
Dillard H. Gates	OSU	Corvallis, Oregon
J. Kent Giles	BLM	Burns, Oregon
Milt Griffith	Deschutes N.F. USFS	Bend, Oregon
John E. Gumert	BLM	Las Cruces, New Mexico
Kelly Hammond	BLM	Portland, Oregon
Grant A. Harris	WSU	Pullman, Washington
Don Hedrick	OSU	Corvallis, Oregon
Tom Heller	BLM	Ely, Nevada
Min Hironaka	U. of I.	Moscow, Idaho
Richard T. Huffman	BLM	Murray, Utah
A. C. Hull, Jr.	ARS	Logan, Utah
Maurice C. Hurd	BLM	Vale, Oregon
Kenneth E. Irons	BLM	Vale, Oregon
Paul M. Jenkins	BLM	Portland, Oregon
Cyril L. Jensen	BLM	Salt Lake City, Utah

Burgess L. Kay	UC-Agronomy	Davis, California
Floyd E. Kinsinger	BLM	Washington, D. C.
James O. Klemmedson	IFRES, USFS	Boise, Idaho
Gerard J. Klomp	ARS	Twin Falls, Idaho
Maxwell T. Lieurance	BLM	Vale, Oregon
Geren W. Long	BLM	Vale, Oregon
Charles W. Luscher	BLM	Washington, D. C.
Bill Malencik	BLM	Reno, Nevada
William L. Mathews	BLM	Washington, D. C.
Cletus R. May	BLM	Vale, Oregon
Leo A. Moser	BLM	Baker, Oregon
Robert B. Murray	IFRES, USFS	Boise, Idaho
Robert Musser	BLM	Elko, Nevada
Mark W. McBride	BLM	Prineville, Oregon
Chadwick W. McBurney	BLM	Vale, Oregon
Carl P. McCrillis	BLM	Portland, Oregon
Myrvin E. Noble	BLM	Washington, D. C.
Reinard B. Okeson	BLM	Burns, Oregon
David S. Orr	BLM	Fillmore, Utah
Richard Page	BLM	Boise, Idaho
Donald L. Pendleton	BLM	Boise, Idaho
Ray O. Peterson	OSU, Ext.	Klamath Falls, Oregon
Willard P. Phillips	BLM	Burns, Oregon
Donald G. Pomi	BLM	Battle Mountain, Nevada
C. E. Poulton	OSU	Corvallis, Oregon
Donald Z. Robins	BLM	Prineville, Oregon
Grant P. Rogers	BLM	Salt Lake City, Utah
Reginald A. Ross	BLM	Vale, Oregon
Warren K. Sandau	BLM	Billings, Montana
R. T. Savage	SCS	Baker, Oregon
W. A. Sawyer	ARS- Squaw Butte	Burns, Oregon
Roger G. Scott	Geigy Agr. Chem.	Yakima, Washington
Susan B. Semenza	BLM	Vale, Oregon
M. T. Shrode	BLM	Baker, Oregon
Justin G. Smith	PNW Exp. Sta. USFS	LaGrande, Oregon
Forest Sneva	ARS-Squaw Butte	Burns, Oregon
Alvin Steninger	BLM	Lakeview, Oregon
Robert A. Teegarden	BLM	Vale, Oregon
S. Duane Town	SCS	Vale, Oregon
Robert B. Turner	OSU	Corvallis, Oregon
Christian Vosler	BLM	Burley, Idaho

Joe Warner	BIA	Warm Springs, Oregon
Dave L. Watson	Chevron Chem. Co. (R&D)	Clovis (Fresno), California
Anthony G. Wielang	BLM	Vale, Oregon
Kay W. Wilkes	BLM	Rock Springs, Wyoming
E. W. Wilton	USFS	Prineville, Oregon
Anton G. Winkel	SCS	Vale, Oregon
Bob Witt	BLM	Lakeview, Oregon
J. A. Young	ARS, Crops Res. U. of N.	Reno, Nevada
Ronald J. Younger	BLM	Medford, Oregon

UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Land Management
State Office
710 N. E. Holladay
Portland, Oregon 97232

Symposium on Management of Cheatgrass on Rangelands

Vale, Oregon

AGENDA

July 27, 1965

1:00-2:30	Introduction	Howard R. DeLano
	Welcome	Max Lieurance
	Remarks (15 minutes each)	Russell E. Getty Glen Fulcher Charles Poulton, OSU W. A. Sawyer, ARS
2:30-3:00	History of cheatgrass - present geographical range and importance of cheatgrass in management of rangelands	Don Hedrick - Professor of Range Management, OSU
3:00-3:30	Break	
3:30-4:15	Cheatgrass an ecological intruder - phenology and habitat of cheatgrass	A. C. Hull, Jr. - ARS, Research Range Scientist, Logan, Utah
4:15-5:00	Cheatgrass yield and precipitation fluctuations	Forrest Sneva - ARS, Research Range Conservationist, Squaw Butte Experiment Station, Burns, Oregon

July 28

8:00-8:35	Relationship of cheatgrass to soils in the Columbia River Basin	Maynard Fosberg - University of Idaho, Moscow, Idaho
8:35-9:45	Autecological characteristics of bluebunch wheatgrass and cheatgrass seedlings	Grant Harris - Professor of Range Management, WSU, Pullman, Washington
9:45-10:00	Break	
10:00-12:00	Program, plans and results at Saylor Creek Experimental Range	James O. Klemmedson - Intermountain Forest & Range Experiment Station Boise, Idaho
1:00-2:30	Studies on rehabilitation of cheatgrass areas	Gerard J. Klomp - Crop Research Division, ARS, Twin Falls, Idaho
2:30-3:00	Break	
3:00-4:00	Fertilizer studies on cheatgrass ranges and range rehabilitation data	Burgess L. Kay - Associate Specialist Agronomy, University of California, Davis
4:00-5:00	Weed control and seeding methods on cheatgrass infested range-lands	Raymond A. Evans - Research Range Conservationist, University of Nevada, Reno

July 29

7:30-10:00	Field trip to cheatgrass area near Vale Discussion by participants	Max Lieurance, District Manager, Vale, Oregon
10:00-10:30	Break	

10:30-11:30	The Medusahead problem	Min Hironaka - Range Management, University of Idaho, Boise
11:30-12:00	Medusahead competition	Grant Harris - Professor of Range Management, WSU, Pullman, Washington
1:00-1:45	Medusahead control and management studies in Oregon	Robert Turner - Range Management, OSU, Corvallis
1:45-2:15	Report on the Medusahead problem in California	Burgess L. Kay - Associate Specialist Agronomy, University of California, Davis
2:15-3:00	Discussion. Questions from participants. Discussion on material covered during three days and how it can be useful in management of rangelands	Glen Fulcher - BLM, Chief Range Management Washington, D. C. William Mathews - BLM, Resource Program Management, Washington, D. C.
3:00-3:30	Break	
3:30-4:15	Summary of presentations on cheatgrass management	Dillard Gates - OSU, State Range Specialist Extension Service, Corvallis, Oregon
4:15-4:45	Summary of presentations on Medusahead	Grant Harris - WSU, Pullman, Washington

July 30

All day — Field trip of Vale Project sponsored by Vale District, BLM

Introduction
by
Howard R. DeLano
Bureau of Land Management
Portland, Oregon

This is the fourth annual symposium type conference held in Oregon by BLM involving both research people and those responsible for range management operations. The first two meetings were held in cooperation with Squaw Butte Experiment Station, with emphasis given to the research work of the station.

Last year a symposium was held on the management of crested wheatgrass. The proceedings were documented and a distribution made to agency people, to universities, and others. It was considered a very worthwhile and successful meeting.

The meeting beginning today will cover a very important grass. Cheatgrass is not the most desirable vegetation, but because of its wide distribution, its abundance and its characteristics, it is an important plant in the management of western rangelands. It is hoped that through listening to the findings of the researchers and through discussion we will obtain some of the answers to our management problems. We have a responsibility of total resource management in the best manner possible. We must take advantage of all available knowledge in meeting this obligation.

I will not go into any details on the material that will be covered the next few days. The people who are on the program are the best qualified experts in their fields and will cover the subject very thoroughly, I am sure. I am looking forward to your full participation and to a very successful meeting.

Opening Comments, BLM Cheatgrass Symposium
Vale, Oregon, July 27, 1965
by

Glen D. Fulcher
Bureau of Land Management
Washington, D. C.

It is indeed a pleasure to be at this meeting and see the large number in attendance. A symposium on the management of cheatgrass is long overdue. We have, for too long, viewed cheatgrass as an undesirable invader that should be eradicated. We have not, as land managers, given enough consideration to the fact that cheatgrass is here to stay.

It is hoped that during our meeting we will get some insights as to how to best manage cheatgrass ranges. Questions that face us are: Should we manage cheatgrass ranges for maximum cheatgrass production as an annual range type? Should we manage for the most effective utilization of cheatgrass but with a goal of a resulting upward trend in range condition toward a perennial range type? Is native perennial grass really more desirable than cheatgrass?

This meeting provides an excellent opportunity to bring the range research people together with those actually responsible for the range management of the public lands. Too often, these groups meet separately, with each tending to go his own way. As a result, we often hear the researcher criticizing the range manager for not utilizing the results from range research in his management practices. And, conversely, you hear the range manager criticizing the researcher as being impractical and isolated in his ivory tower of research where he gets too detailed and technical in his methods to apply his results to an extensive management program. At this meeting, we have the opportunity for each side to express its view. If we have differences, here is the place to discuss them. I think the results will be very beneficial to all of us, and we may find our differences are not very great.

Here in Vale we are in an area where there is an abundance of cheatgrass and, also, it is an area where the Bureau of Land Management is conducting its most intensive range rehabilitation and management program. We hope you will all be able to take the planned field trip, as there is an important story to tell about the potential for multiple use management of our land resources that can be only fully appreciated by seeing on-the-ground results.

Again, may I say I am glad to be here, and I am looking forward to a productive and a thought provoking week.

Opening Comments, BLM Cheatgrass Symposium
Vale, Oregon, July 27, 1965
by

Charles E. Poulton
Professor of Range Ecology
Oregon State University
Corvallis, Oregon

In helping to set the stage for this symposium, I wish to commend the Bureau for organizing and continuing these symposia. They started as one of the high points in professional Range Management in Oregon and now, I see, have grown to include representation from nearly all the western states and from most of the agencies concerned in a professional way with range management. Such symposia are one of the important ways of keeping posted, of learning and insuring professional growth in technical staff people. Where these kinds of reviews and discussions are management-problem oriented, as yours have been, they are especially good.

In my opinion, one of the most critical moves in cheatgrass management (or the management of any annual grass range) is the first decision one must make - namely, do I manage for continuation of the dominance of annuals or for the rapid or eventual return of perennials? Your answer to this question determines: (1) the management alternatives available to you, (2) the relative benefits you can expect, and (3) the risks and immediate or deferred costs you and the Nation may face as a result of the decision. I expect the conference will clarify the alternatives and the costs, benefits, and risks in this decision.

Now let us consider this symposium from the viewpoint of how can we insure and index its immediate and future benefits. Its immediate benefit, I am sure, will be in direct proportion to the amount of your individual participation, discussion, and thought that accompanies each presentation. To the extent that there are good discussions of each topic by you, as well as the formal speaker, we will all go home stimulated with more ideas than we can possibly put into action between this and the next conference. If this happens, and you must <u>make</u> it happen, the future benefits of the conference will be assured--the symposium will have been successful.

How can we assure this success? In a group of this size it will not be easy, but there are two simple requirements: First, each formal speaker <u>must</u> leave adequate time for discussion; and since this symposium is to emphasize <u>management</u> of cheatgrass ranges, he should give his presentation as much management orientation as

possible. In this kind of setting, research conservation needs to be laid aside; and we must speculate together on the interpretations and management implications of all our knowledge. This brings up the second requirement of a successful symposium, us--you and I. You must think with the speakers, ponder what they say in the light of your own experiences, think in opposition to their proposals if you feel the urge or if you disagree, and then enter into the discussion. Regardless of your position on the totem pole, your thoughts, your observations, your ideas not only have a place in this symposium but they are needed. Your idea box is stimulated, speak out! Especially if your most logical thoughts are in partial or even complete disagreement with the proposition of the moment, they may hold the key to solution by bringing up an idea that the researcher has overlooked or by suggesting a new and more fruitful approach.

What then, are the purposes of this symposium? In summary, they are two: First to learn where we stand now as we effectively pool our knowledge; secondly, to "brainstorm", against this backdrop, the subject of the Management of Cheatgrass Ranges. In this brainstorming, there will be a premium on ideas and thoughts. We will learn where our knowledge is weak. We will benefit individually and collectively by pooling what we know. We will learn whether or not what we think we know stands up in the experience of others. Finally, out of an expression and resolution of differences of opinion in this conference we will move closer to the best management solutions on cheatgrass range. Research on these problems will be strengthened. Remember, out of honest, professional disagreement resolved, progress is born.

Management of Cheatgrass on Rangelands
by
W. A. Sawyer
Squaw Butte Experiment Station
Burns, Oregon

Cheatgrass is an invader, a weed, an annual, a variable producer a fire hazard, plus a host of other bad things that might be said about it. These may have influenced us to take a negative attitude about this grass.

Perhaps we should consider the grass in a more positive way. I am sure this will be the attitude of this conference. The following dictates positive thinking.

1. We have cheatgrass -- several million acres -- and we must live with it.
2. The acreage is increasing, not decreasing.
3. Cheatgrass is an effective soil stabilizer.
4. Livestock production on cheatgrass is fair to good.
5. From the standpoint of maintenance, management is less critical than it is for perennial grass.
6. Cheat quickly increases in density, thereby decreasing invasion by less desirable species in wet years.
7. Cheatgrass is a feed resource -- in many places the only range feed available.
8. Cheatgrass was a real blessing 20 to 50 years ago when range was going down in condition because of heavy use.

Land managers, researchers and ranchers must be concerned with cheatgrass as a resource.

There are a great many questions that are either partially answered or not answered at all. Good observation, research, and objective thinking are needed on the problems of cheatgrass use and management. Some of the problems or questions that come to my mind are:

1. Does sagebrush spraying increase cheatgrass density at the expense of perennial production?

2. What effect does use of perennials at various times of the year have on the competitive relationship between cheat and perennial grass?

Some observations would make it appear that deferred grazing (a common practice on cheatgrass ranges to aid in converting to perennial ranges) may favor cheat at the expense of the perennials. Deferred grazing on an excellent condition perennial range may not produce the same response as deferred grazing on a poor condition range in which cheat is well established.

3. We need more information on seasonal intake and digestibility of cheat by livestock.

4. Armed with intake, digestibility, and livestock performance data, we need to build forage production and seasonal use programs so cheatgrass ranges may be properly supplemented and complimented.

I am sure that management of perennial range used in conjunction with cheat range may be more complex than would be the case if there was no cheatgrass range involved.

5. What about use of chemicals in seed bed preparation on cheatgrass range? Chemical curing of cheat for later seasonal use -- can we maintain a stand under this practice?

6. Do soils, soil fertility or site difference influence the competitive relationship of cheat and perennial grasses under various grazing pressures?

7. Can we convert a range now dominated by cheatgrass to perennial grass by management? If so, under what conditions of soil, site, botanical composition and management can it be accomplished?

8. Is fire hazard reduction by heavy use and sustained yield possible?

9. How do we build flexibility enough into a livestock operation to live with the variable production of cheat and still keep the operation practical and economical?

These are only part of the broader questions on which we need more information. Your records of range condition, composition, and use along with your careful observation can provide much of the information needed. Research is needed to answer many of the questions.

This conference can serve a very important function by clearly defining the problems on which information is needed and by stimulating further effort to get those problems solved.

History of Cheatgrass -- Present Geographical Range and Importance of Cheatgrass in Management of Rangelands

by

Donald W. Hedrick
Oregon State University
Corvallis, Oregon

Although the history of cheatgrass provides important background information about its present role on the western range, the response of cheatgrass to grazing management is of more practical concern to range managers. Since its ecological characteristics are well covered by later papers, actual and potential responses to management will be stressed in these brief preliminary remarks.

As indicated by Klemmedson and Smith (1964) and Platt and Jackman (1946), cheatgrass is not a recent arrival but has made its greatest advances since World War I. In fact, I recently learned on a visit to Wallowa County that it was probably introduced purposefully there about 1915 by an itinerant peddler extolling the virtues of a new "100-day" grass. It appears now that he would have been fully justified in referring to cheatgrass as "100-year" grass.

Briefly, the present geographical range of importance to range managers includes most of the Intermountain West between the 6- to 22-inch precipitation zone upwards to 8,000 feet in elevation. This broad ecologic amplitude is tempered by a variety of factors which greatly limit the significant occurrence of this plant to habitats within the 10- to 16-inch precipitation zones up to 5,000 feet in altitude. Using the concept of physiological and ecological limits discussed by Waring and Major (1964) and more recently by Stone (1965), one might diagram the relationship between these for cheatgrass as indicated in Figure 1.

This illustration portrays the role of grazing management (the only limiting factor under reasonable control on dry ranges) as an important determinant of whether the ecological range is greatly restricted (good grazing management) or more nearly approaches the physiological range (poor grazing management). The remainder of our discussion will be concerned with the response of cheatgrass to management. We will first point out the influence that past management probably has had on cheatgrass. Next we will present some results showing its current response to experimental and actual management, and finally speculate on how cheatgrass can be expected to respond to range improvement practices in the future.

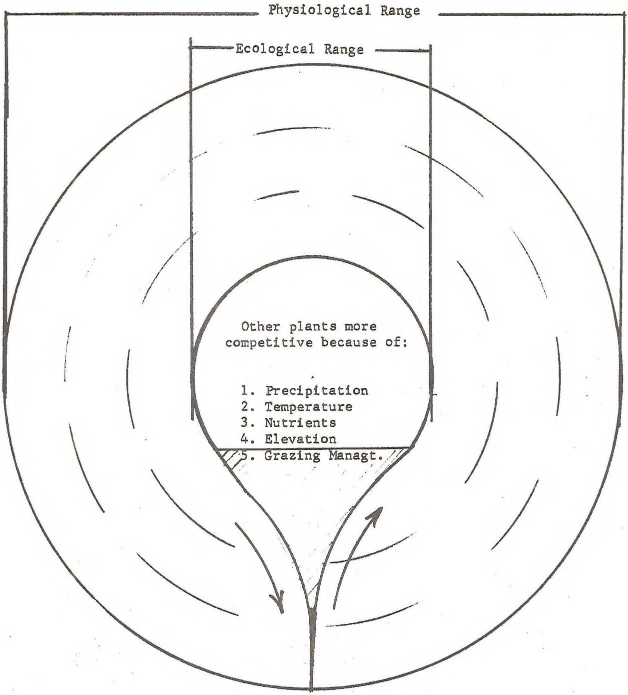

Figure 1. The physiological and ecological distribution of cheatgrass might be likened to concentric circles where the innermost ring is dominated by cheatgrass. There is significantly less as you approach the outer physiological limits because of competition from other species better adapted to conditions which are marginal for cheatgrass.

Since I have little experience or knowledge of cheatgrass ranges per se, i.e, within the restricted ecological range, my remarks will be mostly concerned with the broad area occupied by the dotted circles or in the zone where grazing management is most effective in reducing the cheatgrass component and favoring perennial grasses. To be more specific, I will be drawing all of my illustrations from the so-called High Desert of southeastern Oregon which lies in the 10- to 12-inch precipitation zone between 4,000 and 5,000 feet in elevation. The original vegetation has been described in much of this area by Eckert (1957) and Tueller (1962). It consists of a number of plant communities dominated primarily by an overstory of big sagebrush, Artemisia tridentata, or low sagebrush, (Artemisia arbuscula, with or without western juniper, Juniperus occidentalis. Depending on the site, dominant understory species are: Bluebunch wheatgrass, Agropyron spicatum; Idaho fescue, Festuca idahoensis; thurbers needlegrass, Stipa thurberiana; and Sandberg's bluegrass, Poa secunda. Cheatgrass is usually a minor component in these stands unless the sagebrush cover is disturbed or removed. In Mr. Sawyer's (1964) opinion, the amount of cheatgrass has increased appreciably in southeastern Oregon since the end of World War II. This increase is attributed to: (1) A general decrease in grazing pressure, (2) a later opening date of grazing, and (3) an expanded program of sagebrush control.

Experimental results at Squaw Butte have indicated an appreciable increase of cheatgrass following spraying on native sagebrush-bunch grass range and after applying nitrogen to crested wheatgrass seedings. At Diamond, cheatgrass was observed to be dominant for an eight-year period in a large seeding of crested wheatgrass, but it is now giving way to crested wheatgrass which has been subject to heavy grazing each spring from mid-April to mid-May. In fact, it appears that on improved areas, cheatgrass is more of a problem than on undisturbed sagebrush-bunchgrass ranges in spite, often, of severe deterioration of herbaceous vegetation in the latter. The influence of seedbed preparation (plowing versus spraying) and seasonal utilization (early-late) and intensity (moderate-heavy) studies are needed to better define recommended practices for crested wheatgrass management in this area.

At Ft. Rock where a grazing study on crested wheatgrass has been underway since 1963, the abundance of cheatgrass has been dependent primarily upon two factors -- soil and temperature. The only significant amounts have been found on the coarser-textured soils and in years of favorable spring temperatures (the past two years have been too cold for good cheatgrass development). Grazing periods

of 2-crop and 1-crop grazing primarily during the months of May and June have not as yet revealed any clearcut effects on the abundance of cheatgrass. The heaviest production of cheatgrass in this general area during the same period has been observed on an unseeded burn.

In conclusion, I think we can safely predict that cheatgrass can be expected to increase on favorable sites whenever grazing pressure is reduced or the opening date of grazing is delayed. This increase will be accelerated by range improvement practices that disturb the cover of sagebrush and tend to increase the fertility level of the soil. Research is needed to investigate the possibilities of controlling cheatgrass under these conditions by the judicious manipulation of grazing animals.

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Question: Would early heavy use favor wheatgrass over cheatgrass?

Hedrick: Well, I would say that this is true if the perennials are allowed to recover following heavy early use. In the Burns district there is a thousand acres of crested wheatgrass established in 1955. This is right in the center of the cheatgrass distribution. I would say this has the best utilization possible, in other words there are a bare minimum of wolf plants or poorly used plants, but there is a large population of crested wheatgrass. This is kept down by grazing, but always comes back following spring use and provides a seed crop, and it maintains an excellent cover and has kept out the undesirable invaders.

Question: How long have we had cheatgrass?

Hedrick: As near as we can tell, about 100 years. From what I recall, in view of this grazing study, probably somewhat over 70 years on the west coast. There is one area in Oregon that I am familiar with - Wallowa County - that had no appreciable cheatgrass as recently as 50 years ago. Fields that were abandoned 40 years ago did go through a cheatgrass stage; those that were abandoned 50 years ago did not go through the cheatgrass stage.

Question: Do I understand you correctly? A combination of delayed spring grazing (later grazing in the spring) and lighter grazing - is the net effect beneficial?

Hedrick: That depends on how close you are to the inner circle. If you are very close to the inner circle, it tends to be more beneficial.

Question: I can't see the difference between the ecological and the physiological range.

Hedrick: Let's look at it this way. If there weren't any plants, in the absence of all competition the cheatgrass would be over this entire area. As a result of competition from other plants, it is confined to a much smaller total area. The thing that is important here is that this is not a hard and fast boundary. You can have anywhere from a hard core center to clear out to the outside. This will depend upon a combination of growth factors we have described, and the influence of grazing management.

Question: But I thought that cheatgrass was an invader.

Hedrick: Well, it is an invader except that it did not occur until it was imported. We might have ecotypes scattered all along this range genetically; the entire population of cheatgrass could be described by that outer circle. In terms of the original distribution of cheatgrass, the true ecological range is in the Mediterranean. It has the genetic potential to grow here but never had the opportunity. Now, given the opportunity and environment, it finds some place where it can maintain a foothold regardless of the competition. Other areas into which it can move are those in which the competition is reduced.

Question: You are advocating this heavy spring grazing - are you talking only about reseeded ranges?

Hedrick: The use might vary considerably, depending on the type of vegetation and the particular environment you are dealing with. It becomes more critical from the standpoint of timing with native plants than it does with crested wheat. You have to distinguish between the kinds of plants you are talking about and the environment. This is quite variable here in the west.

Question: Does fire increase cheatgrass?

Hedrick: No, fire does not increase cheatgrass - it just makes it appear to have increased. That is, it doesn't increase the acreage but it increases the poundage by volume. Whether you call that a spread of cheatgrass or not, I don't know. This is true in ponderosa pine areas; there would just be a little tuft here and there - the fire goes through the area - then cheatgrass comes in quite thick. Mr. Sawyer has this to say about it - he says he thinks that when you burn something, in these cheat areas, you get ride of the sagebrush competition then you open up the area and the cheatgrass can come in.

Statement: I think that sagebrush is a better competitor than wheatgrass on cheatgrass areas.

References

1. Eckert, Richard E. 1957. Vegetation-soil relationships in some _Artemisia_ types in northern Harney and Lake Counties, Oregon. Ph.D. thesis. Corvallis, Oregon State Univ. 208 numb. leaves.

2. Klemmendson, J. A. and J. G. Smith. 1964. Cheatgrass (_Bromis tectorum_ L.). The Bot. Rev. 30(2):227-262.

3. Platt, K. and E. R. Jackman. 1946. The cheatgrass problem in Oregon. Ore. State Univ. Ext. Bull. 668:1-48.

4. Sawyer, W. A. 1964. Personal conversation during a research planning conference. Mr. Sawyer is Supt. of the Squaw Butte Expt. Sta. at Burns, Oregon.

5. Stone, E. C. 1965. Ecological and physiological limits of plant species. A review paper given by Dr. Stone to a forestry seminar while on an official visit to Ore. State Univ. in May, 1965.

6. Tueller, Paul T. 1962. Plant succession on two _Artemisia_ habitat types in southeastern Oregon. Ph.D. thesis. Corvallis, Ore. State Univ. 249 numb. leaves.

7. Waring, R. H. and J. Major. 1964. Some vegetation of the California coastal redwood region in relation to gradients of moisture, nutrients, light and temperature. Ecol. Monog. 34(2):167-215.

Cheatgrass -- A Persistent Homesteader

by

A. C. Hull, Jr. 1/
Range Scientist, Crops Research Division
Agriculture Research Service, U.S. Department of Agriculture
Logan, Utah

Cheatgrass (Bromus tectorum) is native to large areas of Europe, Africa and Asia, especially those with winter rainfall. In the Western U.S.A. it found soil, water and climate to its liking. With these hospitable conditions, it homesteaded on large areas. Cheatgrass reached the West just before 1900. It spread rapidly and is still spreading, mainly at the higher elevations. A recent survey indicates that cheatgrass occurs on at least 60 million acres in the 11 Western states.

This discussion is mainly on growth habits and phenology, with some ecological relationships of cheatgrass.

Where does cheatgrass grow? Cheatgrass is a widely adapted plant. It grows from sea level to 9,000 feet elevation, under 4 to 40 inches of annual precipitation, and on soils ranging from gravel to clay. Although cheatgrass grows from the salt-desert shrub to the spruce-fir types, it is most abundant in the sagebrush-grass type in the Columbia and the Great Basins. Here it is a minor part of the climax vegetation. Even well managed ranges show small amounts of cheatgrass.

Like any homesteader, cheatgrass moves into favorable areas not already occupied by other plants. First choice is abandoned farm lands and overgrazed and burned ranges which now often support almost pure stands of cheatgrass. It also grows with other annuals and perennials, sometimes as an understory beneath shrubs such as bitterbrush and sagebrush or under trees such as ponderosa pine. Rabbitbrush and fire-resistant shrubs grow with cheatgrass on recurrent burns.

Growth habits In the West, cheatgrass commences fall growth when rains are sufficient to cause germination. It grows until the weather is too cold. Plants remain dormant during the winter and grow rapidly

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1/ We wish to thank individuals of Agricultural Research Service, Bureau of Land Management, Forest Service, University of Idaho, University of Nevada, and Utah State University for supplying information for this paper.

with warm spring weather and moisture. When germination is delayed until spring, both height growth and herbage yield are usually lower than normal. If seeds do not germinate until late spring, seed heads are seldom produced that summer.

Plants turn from green to purple and then to tan or straw-color as they mature. A purple leaf tinge during winter is normal. Temporary purple coloration may result from freezing or sudden drought. If plants start to dry early and if abundant spring rains occur, new green growth masks the purple coloration.

Stands vary from scattered plants to over 1400 per square foot. The average in an Idaho study was 572. Density, soil, and moisture cause plants to range from a single 1-inch stalk with one floret to multi-stalked, densely-panicled plants 48 inches tall.

Production is variable. At Arrowrock over a 7-year period, cheatgrass yielded from 361 to 3461 pounds per acre; crested wheatgrass (Agropyron desertorum) from 1090 to 2472. Heavy grazing reduces plant numbers by 90% and height by 40%.

Seed production and viability - Cheatgrass produces considerable seed, even in dry years. An Idaho study showed 480 pounds of seed per acre. With 150,000 seeds per pound, this is 1650 seeds per square foot. Seeds collected while the plants are still green, ripen and are viable.

For a few months after dispersal, germination increases to nearly 100%. Laboratory germination begins in 2 days and reached 100% in 4 days. Practically all seeds germinate each year in the field, but seed holds over and retains a high viability if kept dry. Seeds germinate well from the surface, but do better with 1/4-inch covering. Emergence decreases with depth of planting but is still good at the 2-inch depth.

Competitive relations - Cheatgrass is rarely able to replace perennial grasses and shrubs. On the other hand, seedlings of perennial plants only seldom establish themselves successfully when competing with the fast-growing roots and tops of cheatgrass seedlings. In the greenhouse and in the field, both shoots and roots of cheatgrass elongate more rapidly than those of crested wheatgrass.

One bright feature is that perennial plants usually produce an annual seed crop. With good moisture, occasional seed covering, and plenty of time, perennial grass seedlings become established and

eventually replace cheatgrass. Shrubs such as sagebrush and rabbitbrush also invade cheatgrass areas. Cheatgrass in turn can replace most annual grasses and forbs, with the possible exception of medusahead and annual wheatgrass.

Grown in varying densities in the greenhouse cheatgrass reduced the top and root growth of wheatgrass to only 15 - 33% of that produced without cheatgrass. In addition, cheatgrass required only 60% as much water to produce a pound of dry matter as did crested wheatgrass.

Roots - Cheatgrass has a finely divided, deep and spreading root system. Roots extend from 3 to 6 feet in depth and spread laterally from 1 to 2 feet and completely occupy the soil mass. Roots of cheatgrass elongate more rapidly than the roots of perennial grass seedlings.

Soil protection - Cheatgrass tops and roots have been found to protect soil even better than do some perennial plants.

Phenology and morphology - Cheatgrass is a variable plant. Seeds were collected from plants from many areas in the U.S.A. and from the Mediterranean area. When planted at one location in the West, the plants from different areas ranged from 6 to 15 inches in height, varied by 25 days in the beginning of inflorescence and 20 days in drying up. Plants varied in winterhardiness. Those from the Mediterranean area died while those from the Western U.S.A. survived. There was also wide variation in pubescence, compactness of the panicle, and shape of the florets.

Cheatgrass and fire - The more cheatgrass the more fire, and the more fire the more cheatgrass. Also, cheatgrass increases the length of the fire season by 1 to 3 months. A cheatgrass range is 10 to 500 times more likely to burn; and 5 times more men and equipment are needed to control fires on cheatgrass ranges than on perennial grass ranges. Cheatgrass fires weaken and sometimes kill associated plants. Cheatgrass also carries fire to shrub and timbered ranges which would not normally burn.

Fire often temporarily reduces cheatgrass numbers by 90%; height by 50%. The earlier the burn, the greater the reduction. Heavy reduction in plant numbers is beneficial in that it allows seeding perennial grasses on burned cheatgrass areas. On the other hand, a reduction allows weedy plant hosts of the beet leafhopper to invade the burned area.

Enemies of cheatgrass - Smut will sometimes reduce cheatgrass stands over such extensive areas as southwestern Idaho where it occurred in the early 1930's. Snow mold, under some conditions, will completely eliminate cheatgrass stands, as in the winter of 1963-4 in northern Utah. Rusts do little damage to cheatgrass. Spring frost heaving locally kills many plants on newly cultivated areas. Dry weather following early fall germination may reduce cheatgrass considerably and eliminate it on local areas.

Fire and livestock temporarily reduce the amount of cheatgrass, but if continued, they help to spread its domain. The long-time enemies of cheatgrass are good grazing management and seeding with perennial grasses.

Research needed on cheatgrass areas:

1. Ecology of cheatgrass and of plants on cheatgrass infested areas.

2. Management of cheatgrass ranges for: (a) maximum sustained use and production of cheatgrass; (b) replacement with perennials.

3. Control of cheatgrass with herbicides, fire, and machinery.

4. The feasibility and desirability of replacing cheatgrass.

5. Methods and plants to replace cheatgrass.

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Question: Did you say that burning would not increase the amount of cheatgrass but would make it come in earlier after burning?

Hull: Yes, but we are not talking about two years later or anything like that.

Question: What about all the nutrients that are released by these burns?

Hull: Recent studies show that where it is burned had higher nutrients. It does help the first year. There's an ecological reaction on the plant; by the second year we get a tremendous increase. Plants have had a change to regroup themselves; you just do not get an increase the spring following the burn.

Question: Is that earlier feed, or more feed, the second year?

Hull: It's mainly more feed - more volume - nothing earlier.

Question: Your pictures indicate that these are phenological changes - are they due to competition?

Hull: They are due mainly to moisture. You find all these phenological developments in one square foot.

Question: Is this due to time of establishment?

Hull: Well, in competition a lot of things can happen. The different sizes of plant have nothing to do with establishment.

Question: I believe your general observation was that most of the perennial grasses will eventually invade cheatgrass. From my observation there is one exception - bitterbrush. Would you go along with that?

Hull: I would go along with that.

Question: Why?

Hull: I'm not sure I could tell you why, except that our only experience to date indicates this is true.

In bitterbrush stands where we have seedlings produced, and an understory of cheatgrass, at least in the stands that I have seen, were not getting establishment of the young bitterbrush plants. We strongly suspect this is a matter of competition. In fact, we have almost proved it. There may be others in the same category as bitterbrush, in fact I am quite sure there is. There may also be a question of seed coverage. Where we have drilled bitterbrush in cheatgrass, by covering the seed and clearning this area, we got some bitterbrush into a cheatgrass area.

Question: Someone said earlier that later grazing got an increase in cheatgrass. Howard, do you want to defend that?

DeLano: I believe our observations indicate that cheatgrass is increasing in several of our sagebrush ranges in southeastern Oregon.

Statement: One thing that has caused an increase here is the fact that over the years we have tried certain grazing practices which have aided the cheatgrass in making a seed crop. Certain deferred grazing tactics have no doubt assisted in this respect. We can find lots of areas which 20 years ago had no cheatgrass, or very little cheatgrass, where today there is lots of it.

Cheatgrass Yield and Precipitation Fluctuations
by
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Herbage yields of closed communities on perennial grass ranges of the semi-arid regions have been recognized as being dependent on crop-year precipitation amounts. Likewise, yield of cereal grains on drylands in these semi-arid regions have also shown a dependence upon the precipitation received. Thus, when a perennial grass range is lost through fire or mis-management the yields of the new community of which cheatgrass (Bromus tectorum) is a good example, ought also to exhibit some dependence upon the precipitation amounts received. The intent of this presentation is to examine the published record of cheatgrass yield in relation to the fluctuation in precipitation amount during different periods from weather stations adjacent to the sampling sites.

Yield records utilized were those presented by Hull, A. C., Jr. (1949) and Hull & Pechanec (1947) from studies conducted on sagebrush-bunchgrass ranges in southern Idaho. Data analyses consisted of simple correlation and regression techniques and in a final analysis data of certain specific precipitation periods of two stations were pooled following procedures set forth by Sneva and Hyder (1962).

Simple correlation coefficients for 8 selected crop-year precipitation periods with cheatgrass yield at the 3 locations in Idaho are presented (table 1). Combinations of fall and spring (growing season precipitation) produced the highest coefficients; but, the calendar month defining this fall or spring period differed slightly between Arrowrock and Raft River sites. June precipitation did not contribute as much to yield at Raft River as it did to yield at Arrowrock as judged by these coefficients. This is in accord with earlier observations that cheatgrass growth terminated earlier at the lower and drier sites (in this case, Raft River). The precipitation amounts during April, when included, increased the correlation at Raft River but decreased the correlation at Arrowrock. Comparisons between Arrowrock and Raft River in Table 1 suggest that calendar periods may not be expressing similar precipitation periods with respect to forage yield at the two sites. Further evidence of dissimilarity between the two locations is presented by low but significant interstation correlation coefficients of September - October precipitation amount (0.502) and of April, May, and June precipitation amount (0.613).

Table 1. Correlation coefficients of cheatgrass yields with precipitation amounts for the precipitation period indicated at 3 locations in Idaho.

Crop-year	Arrowrock	Raft River	Regina
		"r"	
Sept. - June, inc.	-0.764*	0.537	0.272
Sept. + Oct.	0.657	0.452	0.172
April + May - June	0.703	0.549	0.206
Sept., Oct. + April, May, June	0.804*	0.623	0.208
Oct. + April, May, June	0.876**	0.537	0.196
Oct. + April, May	0.864*	0.848*	0.218
Oct. + May	0.529	0.913	0.280
Oct. + May, June	0.671	0.545	0.268

* Significant at the 5% level

** Significant at the 1% level.

The consistently low coefficients at Kuna for all precipitation periods is not understood. This site is close to Arrowrock, although quite drier (annual precipitation - 10 inches). Interstation correlation coefficients of precipitation amounts of Kuna with Arrowrock were high (0.837)and 0.903) suggesting close approximation of precipitation fluctuations. Part of the difficulty here may be the length of yield record (4 years).

The significant but negative correlation of precipitation during September - June, inc., with cheatgrass yield at Arrowrock is believed to have occurred in part because of the low holding capacity of the soil supporting this vegetation. Also, this site experiences a 3 - 4 month snow cover which also may have adversely affected the over wintering aspects of cheatgrass.

Data for Arrowrock and Raft River were pooled and a single regression of yield on October, April, and May precipitation amount computed. The resulting regression equation was $\hat{Y} = -37.5 + 1.368X$, where $\hat{Y}$ = the yield estimate in percent of the median yield and X = the precipitation amount for October, April, and May expressed as a percent of the median precipitation amount for that period. The standard error of the estimate was 40.4% and the correlation coefficient was 0.829 and significant with n-2 = 11.

The data for Arrowrock and Raft River was also pooled on a fall plus spring combination in which fall precipitation was the same at both (October) but spring precipitation amount at Arrowrock was taken as that received in April, May, and June but only that received in May was considered for Raft River. When examined thusly, the regression equation was $\hat{Y} = -47.6 + 1.48X$ with $\hat{Y}$ = the yield estimate in percent of the median yield and X = the precipitation amount expressed as a percent of its respective median. The standard error of the estimate was 36%, "r" = 0.892 with n-2 = 11.

The correlation coefficients of 0.829 and 0.892 are indicating that about 70 - 80 % of the yield fluctuations are associated with fluctuations in precipitation. However, the rather wide standard errors forego the predictive purpose with a high degree of accuracy. The standard errors obtained are approximately twice that obtained with regressions associated with perennial grass yield and precipitation amount.

In summary, combinations of fall and spring precipitation amounts produced higher correlation coefficients with yield of cheatgrass than other precipitation periods tested. These lend support to the many recorded observations that both fall and spring precipitation are important to subsequent yields of cheatgrass. Delineating precipitation periods by calendar periods may not be the best procedure. Regressions derived by the pooling of data of two stations suggest opportunity for yield estimation; however, rather wide standard errors were obtained. Optimism is expressed for the estimation of cheatgrass yield from precipitation amount but long term yield and concurrent precipitation records are needed to define the relation.

Literature Cited

Hull, A.C., Jr. Growth periods and herbage production of cheatgrass and reseeded grasses in southwestern Idaho. Jr. Rge. Mgmt. 2(4): 183-186. 1949.

Hull, A.C., Jr. and J. E. Pechanec. Cheatgrass - a challenge to range research. Jr. For. 45(8):555-564. 1947.

Sneva, F.A. and D.N. Hyder. Estimating herbage production on semi-arid ranges in the intermountain region. Jr. Rge. Mgmt. 15(2):88-93. 1962.

Relationship of Cheatgrass and Medusahead to Soils in the Columbia River Basin

M. A. Fosberg

Cheatgrass apparently has the ability to grow on almost all soils in the Columbia River Basin except those high in saline and alkali salts. I think this is especially true without competition from other plants. As expressed by Hironaka, the distribution of a species can extend beyond its natural range when competition with other species is reduced.

Stated differently, this could mean the different responses cheatgrass has to kinds of soil properties in combination with kinds of climate is also dependent on the amount and kind of competition from other species.

Hironaka found that going from a more mediterranean type climate in western Idaho and eastern Oregon to a more continental climate in eastern Idaho that cheatgrass gradually decreased in abundance in sagebrush-grass sites studied. This was probably due to a better competitive position for other plant species with changing site characteristics less favorable to cheatgrass.

Dahl has found that in areas of 9-11 inch precipitation in southwestern Idaho that in areas where cheatgrass and Medusahead were in competition with each other, soil and topographic properties affected their distribution. Cheatgrass was domanant on weakly developed soils low in montmorillonite clay. In the same environment, Medusahead was dominant on soils high in montmorillonite clay within 10-12 inches of the surface or soils low in claybut in areas with more favorable topographic positions. Medusahead in the more arid conditions was more dependent on additional moisture in order to survive. Cheatgrass matured in May while soil moisture was still plentiful, while Medusahead did not mature until three weeks later. Therefore, Medusahead was confined to areas of more available moisture either in depression, east and north slopes or on heavy clays. The high clay soils may indicate Medusahead is more tolerant of poor aeration and soils that holds moisture for a longer time. In areas having more than 9-11 inches of precipitation, the depth to clay B horizons became less important. Medusahead did not occur above 4500 feet elevation in southwestern Idaho because of competition from other species. Dahl also found that soils supporting Artemisia arbuscula, the characteristics of which have been reported by Fosberg and Hironaka, were susceptible to Medusahead invasion if sufficiently disturbed. However, with adequate perennial competition, Medusahead was not a problem.

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Question: How are these little slick spots initiated?

Fosberg: Well, I have my own ideas. The moisture pattern in these spots as they now exist - the moisture comes in from the sides, goes into the center and up; this is contrary to the normal movement of water which is generally down. We have traced the movement of moisture in these spots with radio active sulphur so we are pretty certain as to the movement of moisture in the vicinity of these spots. I think they start by disturbance. I think some of these have started within the use of the range by livestock. The reason I think this is because you can find all gradations of slick spots going in this direction. I think something of this type needs much further research to prove, but there is a lot of evidence that supports this.

Question: What is the PH on this?

Fosberg: The PH is not any higher than the lime - generally about 8 or a little below. The reason for this is that you have a high content of sodium salts in the presence of lime.

Question: Does soil compaction have a lot to do with the development of these slick spots?

Fosberg: I do not think so. I think it's change in the normal moisture pattern because of surface disturbance. This is particularly true of silty soils. We have been cultivating these soils for 50 or 60 years under irrigation and slick spots are still there. They are quite permanent. About the only way to get rid of them is real deep plowing where you mix everything together, this works all right under irrigation. I don't think it would work under natural precipitation.

Question: Actually, cheatgrass isn't adapted to the true Mediterranean climate, is it? In California where the true Mediterranean climate comes in, cheatgrass seems to go out. The other bromes, however, come in, like red brome. Cheatgrass doesn't get very common in California until you get on the east slope of the Sierras where you have a different type of climate.

Fosberg: Well, as far as eastern Oregon and Washington are concerned, the climate is approaching Mediterranean. It probably isn't the true Mediterranean, but it is approaching that type of climate.

Question: Do you feel that grazing disturbance might be associated with the formation of these bare spots? If so, do you infer then that the period of formation may be relatively short?

Fosberg: Grazing disturbance here in the western United States has not been a real factor for more than 100 years. Yes, I think so. On silty soils, I think the initiation of these slick spots is possible in a relatively short period. I don't think you will ever see one that developed in close proximity with sagebrush plants or with a group of plants associated with sagebrush. Sagebrush plants become elevated relative to the open spaces. If the grass plants have not been taken out between the sagebrush plants, if ground cover is intact, these would not have formed.

Question: Don't you often find these slock spots on remnants of old anthills?

Fosberg: Occasionally you do find ant hills associated with bare spots, but not all of these bare spots are slick spots. Actually, most of these slick spots that I am familiar with would not have ants associated with them. It may be possible for ants to form around them. Thinking about this, I believe I have seen slick spots associated with ant mounds, but I don't know what causes them.

Question: You probably noticed the slick spots out west of Snowville - were they developed in the same fashion?

Fosberg: I doubt if they were formed in the same fashion. I think that these are associated with the normal accumulation of salt left by the salt lake deposit. There is a similar type thing in the north end of Grass River Valley. I think these are associated with salts that were originally part of the soil. That is just my thinking on it.

Autecological Characteristics of Bluebunch
Wheatgrass and Cheatgrass Seedlings
by

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Wheatgrass seedling survival was determined on field plots to be 39, 69, and 86 percent, respectively, under dense, moderate, and sparse cheatgrass. Wheatgrass seedlings growing in sparse cheatgrass averaged 9.1 and 7.5 times as heavy (green and dry weight, respectively) as wheatgrass seedlings growing in dense cheatgrass. Moisture lost on oven drying amounted to 43 percent for wheatgrass seedlings grown in sparse cheatgrass, and only 16 percent in dense cheatgrass. Concurrent soil moisture determinations indicated moisture was available at less than 15 atmospheres at depths where the larger plants were rooted, but not at levels where the roots of the smaller plants were growing in dense cheatgrass. Soil moisture was available at the lower rooting levels of cheatgrass, even after this species had matured and died. Roots of the larger wheatgrass plants extended to depths of 136 cm. maximum, the smaller plants in dense cheatgrass were rooted to 50-60 cm. depths.

Both species initially produce a primary root system, followed by extensive adventitious roots if the site permits. Adventitious roots of wheatgrass grow out laterally before turning downward. Primary roots of both, and adventitious roots of cheatgrass grow directly downward from the root crown. Cheatgrass roots are more diverse, making fuller contact with the soil. Wheatgrass roots have a heavily suberized endodermis, an adaptation to withstand summer drought; cheatgrass roots do not.

Seeds of both species germinate in the fall, and seedlings live over winter. Cheatgrass seed germinated more rapidly than wheatgrass at 50^{o} F., but the reverse was true at 86^{o} F. The two species did not germinate differently at water potentials of 0, 6.2, and 11.4 atmospheres.

Root growth without competition was studied in glass tubes set in holes in the soil. Cheatgrass roots grew throughout the winter in the field, reaching an average depth of 34 inches by March 9. Wheatgrass seedling roots remained essentially dormant, reaching only 5.5 inches depth by March 9. Numbers of leaves, stems, and roots increased in cheatgrass during the winter, but not in wheatgrass.

Soil temperatures averaged 38° F. at depths where cheatgrass roots were growing, and 34° C. at shallower depths where wheatgrass root tips were located. Wheatgrass roots remained dormant until soil temperatures reached 48° to 50° F. in the spring, and then grew rapidly.

In a laboratory study, x-ray techniques were used to determine soil moisture content, and phosphorus isotopes were used to identify competing root systems. Increasing densities of cheatgrass decreased the average depth of wheatgrass seedling root penetration. Cheatgrass roots grew deeper with increasing wheatgrass densities; this appears to indicate that cheatgrass is inhibited more by intraspecific competition than by interspecific competition with wheatgrass. Cheatgrass roots consistently were found in soil containing moisture available at less than one atmosphere tension. Wheatgrass roots being shorter, were in soil with water available only at tensions greater than 15 atmospheres (approximately wilting percentage).

Cheatgrass plants gain control of the site by growing during winter while wheatgrass, though germinated, remains dormant. Cheatgrass matures 4 to 6 weeks earlier than bluebunch wheatgrass, placing stresses on soil moisture supplies prior to the critical period for wheatgrass. By the time spring temperatures become conducive to wheatgrass seedling root growth, soil moisture tensions have become critically high. Being perennial, wheatgrass must have access to available moisture during summer drought, or succumb. It is suggested that wheatgrass ecotypes capable of growing at low temperatures be sought through selection and breeding.

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Grant Harris, in answering a question from the floor, has stated that wheatgrass is preferred over perennials, around the first of May.

Question: This probably fits the protein curve, doesn't it?

Harris: Yes, this is about the time that the protein is the highest. From the time that wheatgrass gets up until the time it dries up, it is very palatable and highly nutritious, and livestock will eat it in preference to other perennial grass.

Question: Is this also true on burned areas?

Harris: I can't tell you on burned areas.

Statement: We have found this true on reseedings.

Question: If what you are saying is true, if livestock prefer wheatgrass over cheatgrass, then why would delaying your turnout from April to may not favor expansion of the cheatgrass?

Harris: Well, that would depend on how long the cattle stayed on the area.

Statement: I think we are having trouble defining what early spring use is. In some areas the first of May is very early. It depends on where you are. I think most any grass would be preferred to cheatgrass on April 1 in some areas because it just isn't there - that is in any significant amount - enough to graze.

Statement: It looks to me like we are trying to fall into a trap. Really sitting here looking for a pat answer. There are relative palatabilities. I can show you slides where livestock have grazed cheat in preference to other plants, and I can go to the same file and show you the complete reverse. We just must understand the resource we are working with.

Statement: Maybe we are placing over-emphasis on reseeding and using it as an excuse for management. Perhaps we could have much more wisely used our money for other range management practices.

Statement: Sounds to me like we are trying to generalize the situation too much, considering the scope of the area we are considering - geographic provinces and all of the variations. There is a lot of difference. We can't, I believe, take all these perennial species and put them in one flat particular to the way they react, their physiology, their palatability, and the way they react to a given treatment. We found that in our area, on the same calendar day each year, we get a different grazing treatment, different pattern of utilization, depending on the individual phenology of the particular species.

Some of these remarks are true, about the general area of use when these plants should be used, but particularly the use of cheatgrass from somewhere between the middle of April to May 15 is the ideal time to use cheatgrass. In regard to the response of perennials, a lot of these, but not all, perennials respond the same to severe treatment. We normally think that they are damaged most at the reproductive stage, or very near to it. One of our men, Henry Wright who is at DuBois, is working on the effects of burning of perennial species. On part of this work he did some clipping and found very distinct differences in the response to Sitanium hystrix and Stipa comata to clipping treatments - also burning. Wright's work shows it is not just a matter of carbohydrate storage, but rather the entire reproductive cycle - also that dormancy might very well fit into the picture.

Statement: You range managers - you just cannot generalize, you have to gear your management to the particular site involved.

Question: Do you have work on the total weight of cheatgrass vs. wheatgrass?

Harris: No, I haven't had the guts to tackle that project. Let's suppose they both have the same rate of photosynthetic activity and say that it takes a certain amount of cellulose to make the cell walls and other materials, or cell content, etc. Compare these to root plant sections, look at the thickness of the walls of Ag spicatum, compare the thickness of walls of cheatgrass. Cheatgrass plants can grow about four times as much root length for the same amount of photosynehetic materials as wheatgrass plants. Wheatgrass has the ability to live through the summer and become a perennial. This is due to their thick cell walls. They can translocate that deep water which cheatgrass cannot do. However, cheatgrass is not up against this problem. It has an adaptation that makes it grow very rapidly, and penetrate the soil with small roots in every nook and cranny of the soil mantle, and taking all of the water in the area available to it.

Question: Have you done any work on what makes cheatgrass a winter annual?

Harris: I recognize there are lots of areas where we are more sure. I have lots of data which shows that cheatgrass grows in colder

temperatures than wheatgrass. If cheatgrass does not germinate until after April 15 at Lewiston, Idaho, then no seed heads are produced on that plant. If conditions are not just right then cheatgrass will grow and produce only a primary root system, like the pictures we saw yesterday where there was only one floret per plant. I am sure that on these only the primary root system was developed.

Question: Do you have anything on the phenology between crested and bluebunch wheatgrass?

Harris: Yes, crested wheatgrass grows much faster early than bluebunch wheatgrass. On April 5, 1965 I decided to put these plants in the cold room. I had had them in the lab at 70 degrees for about five days; I put them in the cold chamber at 50 degrees. About that time I discovered 50 degrees was not enough; it was not cold enough to slow down the root system. At 34 degrees, it looks like crested wheatgrass is a little better plant for competition with cheatgrass than bluebunch wheatgrass, from these coldroom trials.

Research on Management of Cheatgrass Ranges
by
J. O. Klemmedson and R. B. Murray 1/

Since 1959 the Intermountain Forest and Range Experiment Station and the Bureau of Land Management have been cooperating on investigations to learn how to better manage cheatgrass ranges. These studies are being conducted at Saylor Creek Experimental Range in southern Idaho.

The basic objective of these investigations is to develop improved methods of management for cheatgrass ranges. Although we are perhaps most interested in finding means of converting cheatgrass range back to perennial range through management, we need to know whether this is feasible or even desirable. We need also to know how to manage cheatgrass range per se, for maximum production and maintenance of the optimum stand in terms of continued productivity, maximum nutritive value, and protection of basic resources in the interim before conversion to other vegetation.

The development of systems for grazing for multipurposes requires basic data on both vegetal and animal responses to imposed treatments as background information. Thus, a sequential approach is being followed at Saylor Creek; initial investigations were planned to provide basic data for subsequent studies. Eventually the data will be pooled to design and test systems of grazing for specific management objectives. The work reported herein represents the initial phase of this research.

Vegetal Response to Season of Use Treatments

Since 1960, we have studied the influence of 10 season of use treatments by cattle and sheep on two types of vegetation--cheatgrass range and predominately bunchgrass range. In the spring beginning on April 1, five consecutive 2-week cattle treatments and three consecutive 2-week sheep treatments were applied at a heavy intensity of use. One-month cattle treatments were applied in midsummer and early fall at the same rates (Table 1).

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1/ Intermountain Forest and Range Experiment Station, Boise, Idaho.

Vegetation is of diverse growth form and the pattern is heterogeneous. Therefore the vegetation has been sampled on a stratified basis, and several different techniques have been required to inventory the vegetation. In paddocks represented by the cheatgrass type, two strata are found (1) Bromus-Poa, characterized by Bromus tectorum (cheatgrass) and Poa secunda (Sandberg's bluegrass) and (2) Agropyron, characterized by Agropyron riparium (streambank wheatgrass) as the dominant species. In paddocks represented by the bunchgrass type, these two strata plus a third, the Stipa strata, dominated by Stipa comata (needle-and-thread) and Stipa thurberiana (Thurber's needlegrass), are found.

Although changes in vegetation have taken place since investigations began in 1960, the changes are not so striking that they can be readily observed. Poa secunda has shown the most significant response of the perennial species. The bluegrass response has been most evident when growing in association with cheatgrass. Here density (Table 1) and basal area (Table 2) of bluegrass have been reduced by early spring (both sheep and cattle), summer and fall grazing relative to late spring (May 13 - June 9) grazing. The late spring treatments have evidently favored bluegrass. Bromus and Descurania pinnata have responded in opposite fashion to that of Poa in the Bromus-Poa strata, hence the response of these three species seems related. Whether these responses are the result of one (or two) species being damaged more severely at a certain period or the result of differential grazing use of the species involved has not as yet been determined. Big fluctuations in density between years are characteristic of the annuals and seem more related to year differences rather than to any overall effect of treatment.

Poa secunda responded less significantly to treatment in the Stipa strata than the Bromus-Poa strata. Poa was evidently favored by late spring and fall cattle grazing in this strata. Failure of bluegrass basal area (Table 2) to increase simultaneously with density in treatment 2 (April 15-28) suggests that old plants are breaking up, perhaps due to lowered vigor. Again the annuals, Bromus and Descurania responded oppositely to Poa. Bromus density was reduced by cattle grazing during late May and early June and Descurania by May and early June cattle grazing and late April and early May sheep grazing (Treatments 3, 4, 5, 9 and 10). Why Poa should respond positively in Stipa strata and not the Bromus-Poa strata as a result of fall grazing is without explanation.

In the Agropyron strata (bunchgrass subtype), density but not basal area of Poa secunda has responded significantly. Poa density has increased greatly in response to treatment 4 (late May cattle use) and slightly from treatments 5 and 6 (late spring and midsummer cattle use). Since basal area of bluegrass did not respond significantly for the same periods, the plants must have been breaking up because of lowered vigor. Bromus density increased markedly in the Agropyron strata as a result of most treatments when the associated strata was Bromus-Poa. However, when the associated strata was Stipa, only the mid-spring and summer cattle grazing treatments resulted in increased density of cheatgrass. In the bunchgrass subtype, sheep grazing in the third period was detrimental to the density of Agropyron riparium relative to cattle grazing. Otherwise treatment was ineffectual on Agropyron.

Stipa spp. and Sitanion hystrix are scarce in the cheatgrass subtype; hence these species were sampled with belt transects. In a 15 percent sample of the 20 treatment paddocks in the cheatgrass type, only four Stipa comata plants remained in 1965 of 65 present in 1960. Sitanion hystrix, which is more abundant, was differentially influenced by treatments. This species was adversely affected by May and early June cattle use, and favored by fall cattle use and early spring sheep grazing. Changes in density of Sitanion hystrix for all other treatments are not significant. The loss of Stipa in the cheatgrass subtype is probably a result of heavy grazing on the few plants available. No similar change was detectable in the bunchgrass type where Stipa was quite abundant.

In view of the overall response of individual species to treatments, we can conclude that short term (2 week) grazing treatments even at very heavy rates have not had a very dramatic effect in changing the composition of cheatgrass and bunchgrass range. Equally heavy treatments for longer duration, or repeated grazing within the same year may be effective in modifying the composition of the forage.

Seasonal Forage Value and Grazing Capacity

Cattle Response

For the period 1961-1963, yearling cattle gained an average of 1.51 pounds per day for the April through October grazing season (Table 3). Gains in individual years have varied from 1.30 to 1.68 pounds per head per day. There are apparently several factors contributing to

the significant yearly differences; variation in quantity of particular species available and in quality of feed between years as may be affected by weather seem most important.

The seasonal pattern of gain, with minor variation has been similar in each of the three years (Table 3). Gains have been highest during the spring green feed period; maximum gain (2.10 lbs/head/day) occurs in late spring when forage quality is evidently highest. As the forage dries, quality declines and cattle gains drop steadily through the remainder of the 7-month grazing season. Fall gains have averaged 0.85 pounds per head daily. Difference in gain between seasons is largely an effect of seasonal differences in forage quality. Differences in gain between years may be the result of variation in species composition from year to year and/or the effects of weather on quality. In 1961, when about 50 percent of the available forage consisted of Russian thistle, cattle gains in late summer approached those of the spring period.

Continuous and rotation systems of use have resulted in the same rate of gain in cattle, regardless of intensity in the continuous treatment (Table 4). Apparently under heavy continuous grazing animals still had access to adequate supplies for forage comparable in quality to that in the continuous moderate and rotation moderate treatments.

The productivity of cheatgrass range is expressed here in terms of grazing capacity and animal gains per acre. Grazing capacity averaged 15.3 animal days per acre under continuous heavy grazing for the 3-year period (Table 5). The 3.5 fold difference in capacity from 1961 to 1962 is a reflection of the fluctuation in production of cheatgrass ranges. Capacity under rotation moderate and continuous moderate treatments averaged 8.7 and 10.6 animal days per acre, respectively. Lower capacity results under the rotation system because the forage produced after grazing in the early and late spring treatments is not utilized. No information is yet available concerning trend in vegetation on pastures grazed at the above rates. Thus, we cannot recommend that these rates of grazing are suitable for long-term management.

Since animal gain was similar under all treatments, beef produced is roughly proportional to grazing capacity (Table 6). Beef production per acre (based on gain of tester animals) under the three systems averaged 11.9, 16.2 and 23.5 pounds per acre for rotation moderate, continuous moderate, and continuous heavy systems. No comparable figures are available for bunchgrass range.

Sheep Response

The value of cheatgrass and bunchgrass range for sheep production has been studied in the same paddocks used for vegetation response studies. Hence data are not strictly comparable with cattle gains for the similar period. Sheep have gained an average of 0.32 pounds per head daily over a 4-year period for the 6-week season from April 1 to May 15 (Table 7). The intensity of grazing was heavy. Yearling ewes have gained as much on predominately cheatgrass range as on predominately bunchgrass range. They generally lost weight (0.10 pounds per head daily) during the first 2 weeks of the 6-week season, but gained well during the second and third 2-week periods (0.49 and 0.58 pounds per head per acre, resp.). Transportation to the range, handling, and change in diet are reflected in the early period weight loss. Warmer weather and development of early spring forage were conducive to good weight gains as the season advanced.

Grazing capacity during the period 1960-1964 has varied from 12.0 to 37.9 sheep days/acre on cheatgrass range with an average of 25.1 sheep days/acre (Table 8). On predominately bunchgrass range, carrying capacity varied from 15.5 to 39.0 sheep days/acre or an average of 28.6. Gain per acre by sheep over a 4-year period for the 6-week spring period averaged 12.1 and 12.0 pounds for cheatgrass and bunchgrass range, respectively.

Table 1. 1964 plant density (adjusted from 1962 initial plant density) by treatments for species showing significant changes in at least one treatment comparison

Treatment	Bromus-Poa strata (Pooled data from cheat-grass and bunchgrass subtypes)			Stipa strata (Bunchgrass subtype)			Agropyron strata (Cheat-grass subtype)	Agropyron strata (Bunchgrass subtype)		
	BRTE	DEPI	POSE	BRTE	DEPI	POSE	BRTE	BRTE	POSE	AGRI
	Number of plants/square meter 1/									
1. Cattle Apr. 1-14	2321	54	9	1970	17	12	2033	1233	2	43
2. " Apr. 15-28	3834	51	10	2018	16	22	1948	1020	4	44
3. " Apr. 29 - May 12	2355	33	7	1625	3	14	1342	1120	3	65
4. " May 13-26	2171	14	12	788	2	21	1254	320	11	40
5. " May 27 - June 9	2817	10	13	928	2	23	843	357	6	54
6. " July 8 - Aug. 4	2716	77	9	2145	27	13	1133	1389	7	44
7. " Sept. 9 - Oct. 6	3631	42	8	1749	19	19	1376	221	4	44
8. Sheep Apr. 1-14	3127	48	7	1162	11	15	2092	221	4	44
9. " Apr. 15-28	3477	22	9	1593	5	14	2089	326	4	55
10. " Apr. 29 - May 12	2414	12	9	1638	3	13	1238	780	2	23
Mean of all treatments, 1962	1331	8	10	346	3	15	712	229	4	42

1/ Culms/square meter for BRTE; number of clumps/square meter for AGRI

Table 2. 1964 basal area (adjusted from 1962 initial basal area) of <u>Poa secunda</u> by treatments

Treatment	<u>Bromus-Poa</u> strata	<u>Stipa</u> strata
	- - - - Sq. cm/sq. meter - - - - -	
1	36.7	17.6
2	37.0	42.5
3	48.6	40.2
4	78.9	67.2
5	76.5	55.2
6	47.5	27.3
7	57.5	65.2
8	41.0	38.8
9	59.9	39.4
10	60.7	43.7
1962 $\bar{x}$	65.4	41.6

Table 3. Gain of yearling cattle on cheatgrass range by season and year

Year	Early spring	Late spring	Summer	Fall	Average
	- - - - - - - - - - - Lbs./head/day	- - - - - - - - - - -			
1961	1.48	2.17	1.57	0.98	1.55
1962	2.12	2.30	1.34	0.96	1.68
1963	1.60	1.83	1.14	0.60	1.30
Avg.	1.73	2.10	1.35	0.85	1.51

Table 4. Gain of yearling cattle on cheatgrass range for 3 grazing treatments

Treatment	1961	1962	1963	Avg.
	- - - -	Lbs./head/day	- - - -	
Rotation, moderate	1.52	1.60	1.26	1.46
Continuous, moderate	1.58	1.74	1.34	1.56
Continuous, heavy	1.56	1.70	1.29	1.52
Avg.	1.55	1.68	1.30	1.51

Table 5. Grazing capacity of cheatgrass range grazed by yearling cattle under rotation and continous systems

Year	Rotation moderate					Cont.	Cont.
	Early spring	Late spring	Summer	Fall	Avg.	mod.	heavy
	- - - - - - - - - - - - yearling days per acre 1/ - - - - - - - - - - - -						
1961	3.3	4.8	7.1	6.1	5.3	5.9	6.5
1962	8.2	9.4	16.7	15.4	12.4	14.5	22.6
1963	5.1	7.6	12.4	8.0	8.3	11.5	16.8
Avg.	5.5	7.3	12.1	9.8	8.7	10.6	15.3

1/ Standard animal days/acre, Lucas, H. L., and G. O. Mott. Methods of computing results from grazing trials. Mimeo Rpt. North Carolina State Coll. 8 pp. [n.d.]

Table 6. Beef produced by yearling cattle on cheatgrass range under rotation and continuous systems of use 1/

Year	Rotation moderate: Early spring	Late spring	Summer	Fall	Avg.	Cont. mod.	Cont. heavy
	Pounds per acre						
1961	4.5	10.3	11.0	6.3	8.0	8.0	10.1
1962	17.1	19.5	21.5	14.3	18.1	25.3	38.6
1963	8.6	12.8	11.3	6.2	9.7	15.3	21.7
Avg.	10.0	14.2	14.6	8.9	11.9	16.2	23.5

1/ Based on gains of tester animals, following the approach of Lucas, H. L., and G. O. Mott. Methods of computing results from grazing trials. Mimeo Rpt. North Carolina State Coll., 8 pp. /n.d./

Table 7. Gain (lbs./head/day) of yearling sheep

Period	1961	1962	1963	1964	Avg.
			Cheatgrass Range		
4/1 - 4/14	-.75	.31	-.06	.31	-.05
4/15 - 4/28	.82	.74	.01	.30	.47
4/29 - 5/12	.41	.66	.70	.55	.58
Avg.	.16	.57	.22	.39	.33
			Bunchgrass Range		
4/1 - 4/14	-.78	.07	-.08	.23	-.14
4/15 - 4/28	.83	.61	.08	.48	.50
4/29 - 5/12	.64	.39	.80	.47	.58
Avg.	.23	.36	.27	.39	.31

Table 8. Grazing capacity (sheep days/acre) of cheatgrass and bunchgrass range for sheep

Period of grazing	1960	1961	1962	1963	1964	Avg.
			Cheatgrass range			
4/1 - 4/14	10.0	6.0	19.0	23.1	28.8	17.4
4/15 - 4/28	14.0	12.0	35.8	28.7	32.2	24.5
4/29 - 5/12	15.0	17.9	43.6	36.8	52.7	33.2
Avg.	13.0	12.0	32.8	29.6	37.9	25.1
			Bunchgrass range			
4/1 - 4/14	12.0	9.6	19.0	29.2	27.2	19.4
4/15 - 4/28	24.0	18.4	31.9	32.3	44.7	30.3
4/29 - 5/12	25.0	18.4	47.2	44.9	45.0	36.1
Avg.	20.3	15.5	32.7	35.5	39.0	28.6

Studies on Rehabilitation of Cheatgrass Ranges

by

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In southern Idaho and eastern Oregon about 10 million acres of wildlands are used for range. This area was originally a sagebrush-grass type. The perennial forage grasses have largely been depleted by grazing, and the sagebrush is disappearing because of fires. Cheatgrass and associated species, such as Russian-thistle and tumblemustard, are occupying these ranges, bringing with them many problems.

Cheatgrass, which normally dominates these sites, is an annual, low in volume, palatability, and reliability. Also cheatgrass is highly flammable and is subject to frequent burning, which allows the Russian-thistle and tumblemustard to dominate the aspect. These two broad-leaf annuals are host plants to the beet leafhoppers, which carry the virus causing curly top on sugarbeets and beans. When there are large areas of host plants, leafhoppers are produced in great numbers and pose a threat to the susceptible crops. Replacement of cheatgrass with perennial forage species is the only practical method of relieving this problem.

Cheatgrass is an aggressive and tenacious competitor. It starts growth early and grows rapidly. Its efficient root system quickly depletes soil moisture. Seeded perennial forage species are at a disadvantage in becoming established, especially in the sandy, shallow soils. Limited annual precipitation of about 8 inches intensifies the difficulties in getting perennial forage grasses established. It was because of these problems and the need for dependable forage that these sites were selected to study the replacement of cheatgrass with desirable forage species.

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1/ Acknowledgments and thanks are extended to individuals of Crops Research Division and Entomology Research Division of the Agricultural Research Service and of the Bureau of Land Management for information and assistance.

Two primary avenues are being followed in studies on rehabilitation of cheatgrass ranges. One is cultural practices or seedbed preparation. The other is chemical and depends on herbicides.

Rehabilitation by seedbed preparation - The objectives of the cultural treatments are to find methods of seedbed preparation for controlling or discouraging the growth of cheatgrass and its associates and to favor the establishment of the seeded species. Forage grasses seeded in these tests were crested (*Agropyron desertorum*), fairway (*A. cristatum*), and Siberian wheatgrass (*A. sibiricum*), sometimes referred to as the "crested wheatgrass complex." One group of treatments consisted of cultivating the cheatgrass site, either in the spring or in the fall before or after germination and seeding in the fall or the following spring. In general these seedbed preparations did not efficiently control the cheatgrass and did not result in good stands of crested wheatgrass. Summer fallowing resulted in better cheatgrass control, but usually the crested wheatgrass stands were not satisfactory.

Burning cheatgrass usually reduced the stand but resulted in increased Russian-thistle and tumblemustard stands, which offered considerable competition to struggling crested wheatgrass seedlings and ended in poor seeded stands.

A number of combinations of cultivation and fertilizer applications indicated a tremendous increase of weed species. These tests pointed out the need for absolute control of cheatgrass and its associated components if crested wheatgrass seedlings are to become established. Further studies along this line are contemplated.

A very promising method of seedbed preparation is a system of deep furrows. These furrows are about 4 inches deep and constructed similar to lister furrows or furrows made by a deep-furrow drill. The furrows were made at different times of the year, at different stages of cheatgrass development, and before and after germination in the fall. Seed was drilled in the furrow bottom either in the fall or spring. Good to very good stands of grass resulted. Because of the encouraging results with deep furrows, studies along this line are being expanded, with a number of variations and combinations of treatments contemplated.

One treatment originally included in the seedbed preparation studies was spraying with the herbicide 2, 3, 6-TBA in the spring and seeding crested wheatgrass in the fall. Good to very good grass stands were obtained. Later, additional herbicides were included, and these are being evaluated along with the cultural seedbed studies.

The Wendell enclosure provides a site for testing the adaptability of a wide variety of grasses, legumes, and browse. The plants are started from seed in the greenhouse or by cloning parent plants and transplanted to the nursery. They are irrigated for a year to insure establishment and are then left to fend for themselves. Only the survivors are of further interest for possible use in rehabilitation of the sites being studied.

Control with herbicides - A broad phase of the work at Twin Falls is the use of herbicides. This is distinct from the seedbed preparation studies. A large number of promising weed killers is being examined and field tested in the 85-acre enclosure on BLM land near Wendell. All materials are tested at two rates. On one-third of the plots the herbicide is sprayed, and there is no cultivation of the soil. On another third, the plots are cultivated and then the herbicide is sprayed. On the last third, the plots are sprayed and then the soil is lightly cultivated. All plots were sprayed in the spring and seeded to crested wheatgrass in the fall.

Generally speaking, the kill of cheatgrass, Russian-thistle, and tumblemustard is lowest on the sprayed but not cultivated plots; next, on the cultivation followed by spraying plots; and highest where the plots were sprayed and then cultivated. Grass stands, however, were usually highest on the plots that were first cultivated and then sprayed; next highest on plots sprayed and then cultivated; and lowest on plots sprayed but not cultivated.

There was a wide variation in response to the various herbicides. Some controlled cheatgrass but not Russian-thistle or tumblemustard. Some controlled Russian-thistle or tumblemustard but not cheatgrass. Studies were widened to include herbicides with a broader spectrum so that all weed species might be controlled.

With the more active herbicides, the problems of residues began to appear. There could be perfect weed control but no grass. The seed had been drilled across all plots in a continuous operation, but grass rows stopped or started abruptly at plot borders, according to the herbicide effect.

To study the effects of residues, soil samples were taken from all sprayed plots at 0-2 inches and 2-4 inches. These samples were placed in pots in the greenhouse, and five crested wheatgrass seeds were planted in each pot. The irrigated pots were observed, and notes were made on the number, condition, and growth of crested wheatgrass seedlings. It was found that some herbicide residues completely

inhibited germination. Others produced weak, chlorotic seedlings, which grew only 1 or 2 inches. In other cases the seedlings appeared normal for a while and then died either from the tip or from the crown.

Further studies along this line are planned to learn how long residues persist in the soil and how long they affect seeded species. Possibly some desirable forage species are more tolerant than others.

FERTILIZATION AND REHABILITATION OF CHEATGRASS RANGES

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California has some 5-7 million acres of sagebrush, some of which is already converted to cheatgrass and much more is subject to conversion, the sagebrush being removed mostly by fire. The University of California has been working on problems associated with these ranges since 1954.

All of the work reported here was done on the UC Demonstration Range located 18 miles south of the town of Alturas.[1/] The area is commonly referred to as tableland, and usually grows big sagebrush (*Artemisia tridentata* Nutt.), cheatgrass (*Bromus tectorum* L.), squirrel tail (*Sitanion hystrix* (Nutt.) J. G. Smith), Sandberg bluegrass (*Poa secunda* Presl), and red-stem filaree (*Erodium cicutarium* (L.) L'Her.). Annual precipitation averages 10 inches, with seasonal totals varying widely. The elevation is 4,500 feet, and the growing season is short and variable. Cheatgrass may germinate as early as October or as late as April, but seldom is tall enough to graze before May. Cheatgrass matures about the first week of June and is dry by the end of June. Winter temperatures commonly fall below zero; summer temperatures may exceed 100°F. The soil is gravelly loam over clay on a cemented layer on basaltic bedrock (Yancy series). Total soil depth averages 10 to 20 inches. Livestock use generally is from April 15 to June 15.

Many approaches to range improvement have been investigated in the eleven years work has been underway on the Demonstration Range. All investigations began with removal of the sagebrush. The conversion from big sagebrush to cheatgrass is simple and nearly complete. A single fire kills all the brush. Brush seedlings are numerous the following spring, but are apparently killed by a combination of winter and spring deer and antelope use and spring use by cows.

FERTILIZATION OF CHEATGRASS RANGES

Methods and Materials

Nitrogen fertilization of resident annuals is a popular range improvement practice in the Mediterranean Climate of California (100,000 - 200,000 acres are fertilized annually with 50 to 100 pounds of Nitrogen). Modoc County ranchers wanted to know if and how such a program could be used on cheatgrass ranges.

The cheatgrass site picked for this study had been burned 20 years previously and remained clear of brush. Greenhouse pot tests with barley and lettuce showed the soil to be deficient in both nitrogen and sulfur. These elements were applied in the field to plots 15 by 15

1/ The cooperation of rancher Warren Flournoy on whose land this study was conducted is gratefully acknowledged.

feet at the beginning of the 1955 growing season. Nitrogen (N) was applied at rates of 0, 30, 60, and 120 pounds per acre in ammonium nitrate both with and without sulfur (S) at 40 pounds per acre applied as gypsum. A randomized block design of four replications was used. After the first year nitrogen was reapplied annually in the fall to one replication and the other three left untreated to measure plant responses to the single fertilizer application. The entire study was relocated about a mile away prior to the 1960 growing season. Four replications of each the single application and the annual reapplication were included at the new location.

Yield measurements were made about the first week of June each year by clipping to ground level. The size of plot clipped varied from four square feet on "good" years to 35 square feet on "poor" years in an attempt to achieve similar sampling accuracy on all years. Old plant material was mowed and raked from the plot each fall.

Composition was measured by the step-point method at the same date yield measurements were made (1). Composition was measured in the second experiment only.

Results and Discussion

Single application. Significant forage increases were measured in the second and third years of the first experiment (Table 1) and the first, third, and fourth years of the second experiment. A significant decrease was measured in the second year of the second experiment (a very dry spring*). There was no additional feed produced on the driest years 1955 or 1961, but yield was at least doubled in the good feed years 1957, 1962, and 1963. Additional feed was also produced in the "average" years of 1956, and 1960. Applied nitrogen was apparently gone by the end of the third and fourth years respectively of the two experiments.

Repeated applications. Yields were increased in all but the driest years 1955, and 1961 (Table 2). Thirty pounds of nitrogen plus sulfur at least doubled yields in 8 of 11 years. $N_{60}S_{40}$ was better than $N_{30}S_{40}$ in 7 of 11 years. $N_{120}S_{40}$ was better than $N_{30}S_{40}$ in 8 of 11 years. $N_{120}S_{40}$ was better than $N_{60}S_{40}$ in 4 of 11 years.

Even though 1959 was the driest year of the study, increased yields were recorded. However, it is important to note that this increase contained no cheatgrass. The last effective rainfall was February 19. The yields presented here were tansy mustard (Descurainia pinnata (Walt.) Britton) harvested March 17. Tansy mustard is palatable to stock but dried and shattered before cattle came onto this range in 1959. This

* Precipitation data appear at the bottom of Table 2.

mustard
cheatgrass

Table 1

Effects of a single fertilizer application on oven-dry forage yields

Treatment	1955	1956	1957	1958	1959	1960	1960	1961	1962	1963	1964	1965
	Yields - lbs/A											
	First Experiment						Second Experiment					
Check (None)	210	200	1090	110	0	390	330	40	980	760	610	290
S 40	--	290	1010	60	-	470	400	--	1140	1080	750	350
N 30	--	400	1430	60	-	400	810**	--	1220	1060	740	460
N 60	--	620**	1580	130	-	400	1070**	--	1360*	1430**	930	530
N 120	--	710**	2220*	140	-	390	1170**	--	1660**	1550**	680	530
N 30 S 40	--	430*	1140	80	-	510	750**	--	1040	1310*	860	450
N 60 S 40	--	620**	1610	170	-	460	1220**	--	1300	1240*	940	410
N 120 S 40	--	680**	1600	200	-	540	1430**	10	1860**	1800**	860	360

* Significant at .05 level
** Significant at .01 level

Table 2

Effects of repeated fertilizer applications on oven-dry forage yields

Treatment 1/	1955 2/	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
	Yields - lbs/A										
	First Experiment					Second Experiment					
Check (None)	210	250	1100	20	0	330	120	920	970	940	320
S 40	-	170	610	20	-	400	-	700	1130	750	260
N 30	-	550	2320	460	-	810**	-	1860**	4000**	1440	720
N 60	-	740	3370	1170	-	1070**	-	1940**	3620**	600	1340**
N 120	-	780	2910	430	100	1170**	-	2060**	4310**	750	980*
N 30 S 40	-	610	3110	460	420	750**	-	1970**	3640**	1330	930*
N 60 S 40	-	850	5690	2050	880	1220**	-	2360**	5100**	1840**	1560**
N 120 S 40	-	790	6200	3300	810	1430**	40**	2710**	7020**	3070**	2320**
Precipitation (inches) 3/	8.73	14.54	15.48	17.40	4.92	7.28	5.37	9.75	14.36	12.44	15.13

1/ Rates of nitrogen (N) and sulfur (S) are given in lb/A. Nitrogen was applied each fall, sulfur only in spring of 1955 and fall of 1959.

2/ Data 1955 - 1959 are one replication only.

3/ Data 1955 - 1958 are USFS - Alturas. 1959 - 1965 are measured on experimental area.

* Significant at .05 level

10 - 15% higher

** Significant at .01 level

is the only species at this site which has been observed to produce earlier feed due to fertilization. Cheatgrass may change in color and increase in ground cover, but has not produced additional grazable growth as the result of fertilization.

Analysis of tansy mustard in 1958 and 1959 showed a protein content of 30.8% and 31.6% respectively. Also nitrate nitrogen was 2750 ppm in 1958 making nitrate poisoning a potential hazard (3). This production of early feed by fertilization of tansy mustard was not observed in the second experiment (1960-1965). Even though 1962 was a "mustard year", total yields and ground cover were high and included considerable cheatgrass. However, all increases in herbage production due to fertilization in 1962 were due to mustard;- cheatgrass production was not increased by fertilization. All other years, 1960-1965, the composition was predominantly cheatgrass whether fertilized or not.

The addition of sulfur to nitrogen produced increased yields over nitrogen alone in 6 of 11 years. In general these were either exceptional cheatgrass years or "mustard" years.

Total ground cover was increased by fertilization in all years 1960-1965 except the driest year 1961. Ground cover varied from 3% to 45% on the check and 1% to 100% on the $N_{120}S_{40}$ treatment.

Conclusion

Fertilization of cheatgrass may frequently increase yields and also favorably influence species composition, seasonal availability of forage, and increase ground cover. However, fertilization is not a dependable means of increasing cheatgrass and associated species every year. On the three poorest feed years of the eleven year study fertilization either did not increase yields or produced all mustard which shattered before the normal grazing season. Also the increases in yield would have to be carefully compared to costs of fertilization. Although yields are frequently increased several fold the non-fertilized yields are low and thus cost per ton of additional feed may be high. Also the impressive yields obtained with fertilization on a "good year" probably represent wasted feed as only rarely would it be possible to utilize this feed.

BURNED RANGE COMPARED TO SAGEBRUSH

Local rancher interest in sagebrush burning demanded we measure the difference in forage yield between a sagebrush and cheatgrass range. Cages were placed on alternate sides of a road which had served as a fire break some 20 years previously. As expected herbage yields were considerably greater on the burned or cheatgrass side - from 8 to 16 fold greater than on the brush area. An attack by the sagebrush moth (*Aroga websteri*, Clark) in the fourth summer of the study increased the yields on the sagebrush area to only slightly less than the cheatgrass area the following two years.

PERENNIAL GRASS SEEDING

Seeding with perennial grass species is a satisfactory method of improving cheatgrass range. Extensive testing has shown intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), pubescent wheatgrass (*A. tricophorum* (Link) Richt.), and big bluegrass (*Poa ampla* Merr.) to be the most promising grasses. Intermediate and pubescent wheatgrass are preferred over crested wheatgrass (*A. desertorum* (Fisch.) Sehult.) because of their ease of establishment and longevity. They thicken up the stand as they get older while crested stands only get poorer as plants are killed. Crested wheatgrass seldom volunteers from seed in this area. Spring seeding using cultivation or herbicides to control competition from cheatgrass is the preferred method of establishing perennial grasses. Control of rodents during the period between seeding and germination is felt to be essential.

Big bluegrass may produce as much as three times the forage of any *Agropyron* sp. on a dry spring. However, problems of establishment and management have kept us from a general recommendation of this species.

WHEATGRASS FERTILIZATION

Fertilization of perennial grass species is not practical at this site. Details appear in another paper (2). Applied nitrogen increased competition between cheatgrass and wheatgrass for soil moisture and resulted in death of the wheatgrass. Grazing further increased this effect. Forage increases occurred in two of four years, but did not justify the cost of fertilization.

CHEATGRASS AS A WEED IN WHEATGRASS SEEDINGS

Cheatgrass is a major component of wheatgrass stands. However studies show that spring grazing (April 15 - June 15) favors the wheatgrass and discourages the cheatgrass and will reduce cheatgrass to a minor part of the composition. Herbicide studies indicate many materials will selectively remove cheatgrass from *Agropyron* sp. without damage to the wheatgrass.

Literature Cited

1. Evans, R.A., and R.M. Love. 1957. The step-point method of sampling - a practical tool in range management research. Journ. Range Mangt. 10: 208-212.

2. Kay, B.L., and R.A. Evans. 1965. Effects of fertilization on a mixed stand of cheatgrass and intermediate wheatgrass. Journ. Range Mangt. 18: 7-11. Vol 19: 1966

3. Tucker, J.M., D.R. Cordy, L.J. Berry, W.A. Harvey, and T.C. Fuller. 1961. Nitrate poisoning in livestock. Calif. Agr. Exp. Sta. Circ. 506.

Weed Control and Seeding Methods on Cheatgrass-Infested Rangelands

by

Raymond A. Evans, Richard E. Eckert, Jr., James A. Young and Burgess L. Kay 1/

Control of cheatgrass (Bromus tectorum L.) and other herbaceous weeds at time of seeding perennial grasses and proper seedbed preparation are critically important in seedling establishment of cleared big sagebrush lands in Nevada and Northeastern California.

Studies on weed control and seeding techniques in cheatgrass-infested rangelands were begun by us in 1958 and continued until the present time. Two principle methods show promise in these studies. One is a chemical-fallow technique where a soil active herbicide is applied one year and perennial grasses seeded the next. On a physiological basis, none of the soil active herbicides tested has shown selectivity between cheatgrass and seedlings of the perennial grasses. However, after waiting one year between spraying and seeding, perennial grass seedlings are not injured to an appreciable extent by the herbicide. The year of spraying, cheatgrass and broadleaved annuals are controlled by the herbicide. This eliminates the weed seed production for that year and also conserves soil moisture which would have been used by the growing weeds for the seeding year.

To date, atrazine at 1 lb/A has been the best herbicide and rate in this method under our conditions.

During the seeding year, density of cheatgrass has been markedly reduced on the fallow areas but in some years broad-leaved weeds have increased. Under these conditions, furrowing at time of seeding and/or spraying broad-leaved weeds the following spring with 1 lb/A of 2, 4-D have resulted in good stands of intermediate and crested wheatgrasses.

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The other method calls for spraying paraquat and seeding perennial grasses at the same time. Paraquat kills grass on contact, and is deactivated upon soil contact by being adsorbed into the soil particles. This unique property permits simultaneous spraying for cheatgrass control and for seeding perennial grasses. Under our conditions, the spraying-seeding operation is generally confined to spring, because cheatgrass usually does not germinate and emerge in the fall.

In general, 1/2 to 1 lb/A of paraquat gives adequate weed control to establish perennial grasses. The making of a small furrow in the drilling operation enhances stand establishment in this technique.

Much research experience has been accumulated on both methods and now perennial grasses can be seeded into cheatgrass-infested rangelands with chemical weed control and proper seedbed preparation. However, like other seeding methods, the degree of success depends on precipitation and the site potential.

Neither atrazine nor paraquat have been registered for range weed control so these techniques cannot be recommended for use at this time.

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Question: Ray, would you lose that stand in another year due to mustard competition:

Evans: Yes, we may lose those plants.
(The last question had reference to a slide which was shown - some crested wheatgrass seedings in which there was a great deal of tumblemustard invasion).

The Medusahead Problem

by
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Medusahead (Elymus caput-medusae L. or Taeniatherum asperum (Sim.) Nevski) is an introduced winter annual grass of low palatability that has replaced cheatgrass and other annuals on several million acres of rangeland in the Pacific Northwest and California. Although introduced into this country in the late 1880's, widespread invasion of medusahead did not begin until the 1940's.

Replacement of cheatgrass by medusahead has occurred in that portion of cheatgrass range that receives 10 or more inches of precipitation annually in southwest Idaho. Toward the zeric end of its distribution, medusahead is confined primarily to soils that are high in montmorillonite clay. Cheatgrass dominance is retained on weakly developed soils or soils that possess properties of low water holding capacity. As precipitation increases soil properties become less influential in determining the distribution of medusahead.

In the sagebrush-grass region, medusahead represents the highest annual grass stage in secondary succession. Medusahead is better able to make fuller utilization of site resources than cheatgrass. Replacement of cheatgrass is apparently due to the higher reproductive success of medusahead, being 10 to 35 percent more successful than cheatgrass. The reason for the higher winter mortality of cheatgrass is not understood.

A conspicuous feature of medusahead range is the tendency for this species to accumulate large amounts of old growth. This is due to the small amount of forage removed by livestock and the slow decomposition rate of medusahead litter. The silica content in the ash component of medusahead forage is considerably higher than in cheatgrass and is suspected as the primary reason for its low palatability.

Even under protection the succession from annual grass to perennial grass is slow. The introduction of both cheatgrass and medusahead in the natural successional sequence might in part explain the slowness of the return of perennials. Our native perennials did not evolve in the presence of these two aggressive species.

Utilization study of medusahead range shows that cattle are highly selective in the species they graze where the range is lightly stocked in the spring. In relation to its abundance and distribution, medusahead was the least grazed of the more important forage species present. About 5 percent of the plots with medusahead were grazed. Cheatgrass was sparsely scattered and had a grazed plot frequency of 8 percent. Species such as Sandberg's bluegrass, squirreltail and bluebunch wheatgrass were readily grazed. Grazed plot frequencies of these species ranged from 40 to nearly 65 percent. Of the forbs, salsify (Tragopogon dubius) was the most sought after species, followed closely by agoseris. These two species had grazed plot frequencies of 85 and 75 percent respectively.

Cattle can be forced to graze medusahead in the spring. In a heavily grazed field more than 85 percent of the plots that contained medusahead were grazed. Only a few cheatgrass plants and no perennials were encountered in the sampling. Medusahead litter was conspicuously lacking.

To make fuller use of medusahead creates problems. Cattle will graze medusahead more freely where the old growth is absent. With heavy use the old growth does not accumulate and greater use of medusahead can be had during the pre-head stage. The more desirable species are also more heavily grazed and are either killed or severely damaged. Under these conditions less palatable species such as annual sunflower tend to flourish during the summer months.

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Question: Is die-out the same as choke-out?

Hironaka: No, this is not the same. In some areas where there is a lot of litter we don't get this so-called choke-out, where we do on areas that don't have so much litter. Some years we have a great abundance of these die-outs, and the next year we do not.

Question: How large is the probable spread of Medusahead in the west?

Hironaka: Well, I think there is a very large potential for its spread.

Question: Is there a grazing management use to prevent this spread?

Hironaka: No, the only way to stop this thing from increasing would be to spray the grass, or through reseeding.

Question: I might have misunderstood, and not gotten all your comment. Did you say Medusahead was the highest plant in the secondary succession of sagebrush-grass type? You said that the earlier maturing species would replace the later maturing species, but wheatgrass is earlier maturing than Medusahead. What is your explanation for this?

Hironaka: This is true. It has something to do with winter mortality. Under natural revegetation and management, do we have to go back to the cheatgrass stage and then on to perennials? It's in the Medusa stage now; we would have a hard time putting it back into cheatgrass.

Question: You have observed in your studies - when is the plant most palatable?

Hironaka: I would say in the early spring, but it must be available. Litter material may limit its availability. Of course, you can fertilize it and make it more palatable.

Statement: You would encourage cheatgrass if you fertilized Medusahead.

Hironaka: Yes, I would say so.

Question: Could you maintain this?

Hironaka: Well, no.

Statement: I had a rancher tell me that his cattle ate this Medusahead in the fall after a storm.

Hironaka: Yes, I have seen this. Particularly when there wasn't anything else to graze.

Statement: It seems to me on this succession question - a natural tendency would be to sooner or later go through one of these long lasting Sitanion hystrix stages, then, given a seed source from these other perennial grasses, eventually we would get a perennial grass stand. But how long can we afford to wait? We're going to have to devise management procedures that will speed succession as rapidly as possible. In any case, it's going to be slow on many of these sites.

Question: Min, would you consider this plant a good watershed protection plant?

Hironaka: I would say yes and no at the same time. If it is there, it would be a good soil binder, but you have an earlier fire hazard, and if it burns off then you don't have much of a watershed.

Question: Is it as great a fire hazard as the cheatgrass?

Hironaka: Yes, I think so.

Question: Will Medusa hold the soil as well as perennial grass?

Hironaka: I would say no, because the roots of both Medusa and cheat break down and decompose during the summer and fall. In other words, you are losing your root system, therefore you cannot bind the soil.

Medusahead Competition

by
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It is quite apparent that, at least on certain sites, medusahead plants are able to displace cheatgrass plants in field competition. The mechanisms by which this occurs are only poorly understood.

Cheatgrass seedlings frequently outcompete seedlings of other species by: (1) producing deeper root systems during the winter, and (2) depleting the available soil moisture below the reach of roots of other species early in the season as a result of its early phenology. To be competitive, medusahead must meet these usual advantages of cheatgrass, or interfere in some way with its normal growth.

Laboratory and field measurements indicate that medusahead seedling roots grow at an even faster rate than cheatgrass roots. However, comparable stages in medusahead phenology are two to three weeks later than cheatgrass. It might be expected, then, that cheatgrass, maturing earlier, would deplete the stored soil water supply before medusahead could reach maturity.

Even though cheatgrass roots normally reach depths of four feet, only the surface two feet of soil moisture is depleted by the time cheatgrass matures. Cheatgrass roots are so constructed that they cannot efficiently translocate deep soil moisture through dry surface horizons. On the other hand, medusahead roots are protected by a heavily suberized endodermis layer, and can apparently continue growth in competition with cheatgrass after the latter species has matured. This relationship may explain why medusahead is often reported to compete best on north exposures or heavy soils where late-season moisture stress might be expected to be ameliorated.

The points described above might explain why medusahead can grow with cheatgrass but do little to explain why cheatgrass thins out and often disappears from medusahead stands. Medusahead apparently has several influences on the site after invasion which in total effect result in the failure of cheatgrass to successfully compete.

Experimental evidence indicates that the dense litter cover which accumulates under a medusahead stand is important in the competitive relationship with cheatgrass. Cheatgrass fails to grow under three inches of litter cover; it makes no difference whether the litter is medusahead, cheatgrass, or wheatgrass straw. It appears that light is the limiting factor.

Several other minor factors are also suspected of contributing to the dominance of medusahead over cheatgrass. These include greater rate of leaf height growth, more rapid germination, greater germination under adverse moisture and temperature conditions, greater seedling resistance to dessication, lower critical nitrate level requirements, and others.

Recent studies failed to show a preference for cheatgrass herbage over medusahead in diets of common small animals.

Genecological studies indicate a surprising amount of variation in medusahead collections from various range areas in Washington, Idaho, and Oregon. Marked differences have been noted in amount and rate of germination, phenology, and morphology. A second year study, using seed produced in a central garden, will eliminate the variability in the first year trials resulting from seed produced on different sites.

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Question: Does the thicker endosperm have any effect on the use of herbicides?

Harris: The old part of the root does not absorb very much; the new part does the absorbing. Actually the older part of the root acts only as a passageway.

Question: For shallow applications of chemicals near the surface?

Harris: Well, I don't know.

Question: have you had a chance to look at different ecotypes of Medusahead?

Harris: We feel that the variation in the California ecotype study was sufficient to give reason to think we would get different results (competitions) from one ecotype to another ecotype. So we want to make sure we know what we're working with. Jack Nelson is very busy on ecotype study - he has 21 collections from Eastern Washington, Oregon and Northern Idaho and we have gone through the first year. We discovered that the conditions under which a seed is produced has quite an effect on its germination and its early

establishment. That is, if it is established under tough conditions, the seed may not be very well filled, may not germinate very rapidly, and may not put down a root very rapidly. So we thought we would like to have all the seeds in this ecological study have an equal chance of being filled out, on the conditions under which they were developed. We have two gardens under which we are growing - one at Pullman with 20 inches of precipitation and one at Cooper under about 10 inches of precipitation, where we're growing these, and of course we observe the phenecological development. This year we bagged florets on these plants before anthesis, so we wouldn't get crossing in our garden, and this is the thing that Jack Nelson is doing now - collecting the seed in these bagged plants so we can keep our ecotypes clear and pure and run them through next year.

Question: You haven't made any measurements on the relative epidermal thickness of these?

Harris: No.

Statement: The reason I am asking is that we have a test in California where paraquat is killing medusahead - Robert Turner isn't having that kind of luck.

Harris: Well, perhaps you should send us some of your seed so we can put it in our garden. If you get these ecotypes close enough together geographically, I am sure that they will cross.

Question: What did you sterilize your litter with?

Harris: We have three or four of these Army mattress sterilizers - at the University we are like BLM, we get surplus things if we can. We gather our straw in burlap bags and put them in these autoclaves - clamp down the lid - turn on the steam - leave them 24 hours. It does a good job.

Question: This is to remove any pathogens?

Harris: It will remove pathogens, and it could possibly take out inhibitors which we were watching for.

Question: As the primary root dries up, won't Medusa and cheatgrass have the ability to send out advantitious roots?

Harris: Sometimes I think I have observed differences where Medusahead has more ability to do this.

MEDUSAHEAD CONTROL AND MANAGEMENT STUDIES IN OREGON

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Medusahead, an introduced winter annual grass weed,is currently a problem on range and pasture lands of Oregon. The weed is of practically worthless value as forage for both cattle and sheep, and competes vigorously with cheatgrass and other annuals on deteriorated rangelands.

Research has been in progress at Oregon State University since 1961 directed toward the control and replacement of medusahead. This work is sponsored as a cooperative project by the Bureau of Land Management. The main locations of the research has been in Benton, Wasco, Baker and Malheur Counties.

On sites containing medusahead which are suitable for tillage, control of the weed and replacement by perennial type seeded forage is easily attainable. Conversely, on sites which are shallow, steep, or rocky, with an inherently low forage potential, the problem of medusahead replacement has no immediate solution by conventional means. Investigations in eastern Oregon have shown that spring seeding of wheatgrasses (intermediate, pubescent and crested) following plowing in the spring has given excellent stands of the perennial grasses on a site where these are adapted.

Several herbicides have been tested and found to give good control of medusahead. However, residual activity of most of these limits seeding following weed control. Of the many herbicides screened and tested each year at Oregon State University, three are considered to have a place in medusahead control. Atrazine and bromacil (Hyvar-X by du Pont's label), both soil sterilants, have been effective in controlling medusahead and cheatgrass at rates of 1 pound per acre (active material) applied in late fall and ½ pound per acre applied in early spring or fall, respectively. These herbicides are particularly useful for selective control of medusahead and cheatgrass from stands of native bunchgrass or established wheatgrass for usually two or more seasons.

Marked increase in vegetative and reproductive vigor have been recorded. Results of plots treated with atrazine (2 pounds per acre applied in 1962) are shown in Table 1 for a comparison with control plots.

A striking change in annual composition was noted at this site (Stripe Mountain Exclosure) between 1963, a good cheatgrass year, and the latter two years. Between 1963 and 1964, cheatgrass frequency (2 square inch plot size) was reduced from 95 to 40 percent in the control plots. Moreover, the plants were extremely small and depauperate in 1964 and 1965. Medusahead, on the other hand, is patchy at this site but increased from 6 to 11 percent from 1963 to 1964. These plants appeared normal in vigor and

Table 1. Height and vigor of vegetative and reproductive clumps of Agropyron spicatum following treatment with atrazine.

Agsp Clumps	Control			Atrazine		
	1963	1964	1965	1963	1964	1965
Vegetative height	9.7"	11.6"	13"	16"	18.4"	*
Reproductive height	19.5"	18.9"	26"	26"	30.4"	32"
R/V ratio	1/5	1/5	3.4/5	3.3/5	4/5	4.7/5
Max. number of heads/clump			325			125

* Too few plants for an average

reproduction. Except in patches of medusahead, the annual forage Amsinckia intermedia and sunflower, Helianthus annuus, have been the dominants of the annuals. These were almost completely lacking in 1963, yet had frequency values of 46 and 24 in 1964!

Atrazine (1½ pounds per acre applied in spring 1962) was also effective for selectively removing medusahead from an infested pubescent wheatgrass stand. Average yield increased from 840 to over 1400 pounds per acre when clipped the second growing season following treatment. Medusahead, on the other hand, was reduced from 470 to 14 pounds per acre. Total yield of dry material per plot, however, was of little difference between treated and untreated. Atrazine has repeatedly given a dark green "fertilized appearance" to Agropyron spicatum the first growing season following treatment, resulting in increased denseness and vigor of the clumps.

Atrazine injures and kills Poa secunda to a progressive degree of severity with rates of 1 pound per acre and more. Bromacil (½ pound per acre), however, has exhibited a selectivity for removing medusahead and cheatgrass without injury to Poa secunda. Moreover, the vegetative and reproductive vigor of Poa secunda was markedly increased.

Atrazine and bromacil, although cleared by the Federal Food and Drug Administration for use on several crops, have not been given clearance as yet for use on pasture and rangelands.

IPC (4 pounds per acre) plus 2,4-D (3/4 pounds per acre), when applied in late fall or winter, has given adequate control of medusahead and cheatgrass. Crested wheatgrass germination has been attained by drill seeding in the spring following application. IPC residue is considered to be completely absent for a fall seeding.

Sheep were used in an experiment in Baker County on a rocky, medusahead site as a means of trampling crested wheatgrass seed into mineral soil, following an IPC treatment. The IPC (2.5 pounds per acre) was applied in mid-November, 1963, and the grazing and seeding followed in early April. Control of medusahead and cheatgrass was only fair but wheatgrass establishment was remarkably good in patches. The mean of three replicated paddocks, 1/20 acre in size, was .1 plant per square foot. Seeded and grazed control plots were essentially void of crested wheatgrass establishment.

Paraquat, a herbicide which has been reported to give good annual grass control, yet with no soil residue, has given very poor medusahead control under eastern Oregon conditions. Medusahead vigor is actually increased from this herbicide, with the appearance of being fertilized!

Cattle have been experimentally grazed each year since 1962 in Baker County on a dense medusahead stand. Table 2 shows the results of the 1963 grazing under fertilized and non-fertilized conditions.

Table 2. Comparative medusahead clippings (lbs./acre) following 85 lbs./ acre of nitrogen and non-fertilized.

	Fertilized Non-grazed	Fert. Grazed	Utiliz. Percent	Non-fert. Non-grazed	Non-fert. Grazed	Utiliz. Percent
Medusahead	1347	88	93	551	384	30
Other grasses	104	17	84	54	31	43
Forbs	39	4	90	22	8	64
Dry matter	1490	109		627	423	
Litter	251	50		215	180	

The cattle relished the fertilized plots and had removed practically all of the vegetation within an hour after entering the pasture. Utilization was essentially lacking on the non-fertilized areas. Medusahead was in the boot stage on the fertilized plots and in early head emergence on the non-treated when the cattle entered. They had access to the pasture from May 29 to June 5.

Sheep have been grazed a site on a hill pasture infested with medusahead near Corvallis for three years. The treatments include EARLY GRAZED (mid-April), LATE GRAZED (late May), EARLY-LATE GRAZED (mid-April followed by late May grazing), EARLY MOWED, EARLY-LATE MOWED and CONTROL. After two years, the early-late mowing has reduced medusahead considerably. The early-late grazing treatment has also been effective, but to a lesser degree.

California oatgrass (Danthonia californica) vigor increased measurably as a result of the release from medusahead and other annual grass competition. Compared with a control basal diameter average of 3.5 centimeters, the values for early-late mowed and early-late grazed measured in 1965 were 6.7 and 4.9, respectively.

THE MEDUSAHEAD PROBLEM IN CALIFORNIA -- WHAT PROGRESS IS RESEARCH MAKING?

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The medusahead (Elymus caput-medusae L.)[1/] acreage in California is still growing in both the Mediterranean and High Desert areas. It can be found in every county in the north half of the State as well as five counties in the south.

Although it has been shown by Lusk et al. (6) to be palatable to sheep and observations indicate it is also palatable to cows in at least the vegetative stage, it is still an undesirable range plant. The persistent nature of the litter may protect early growth from grazing. Although this may not always be undesirable, it is frequently a problem in management and burning may be required to remove the litter. Perhaps the most objectionable characteristic is its habit of growing in such dense stands that it may exclude other plant species - particularly legumes.

All California rangelands are nitrogen deficient. Therefore in order to maximize forage production it is necessary to either add nitrogen from a sack or maintain an efficient legume in the stand. Therefore current research efforts are directed at establishing or increasing legumes in the range forage. Where adapted we are also interested in establishing perennial grasses because of the better seasonal distribution of forage.

Herbicides to control competition during seeding in Mediterranean climate.

Paraquat has shown great promise for weed control during seeding in the cheatgrass (Bromus tectorum L.) ranges of northeastern California as reported by Evans et al., earlier in this conference. With this success it seemed desirable to try a similar technique in the not-so-similar mediterranean-type climate which most of California enjoys.

A common approach to improving these ranges is the planting of good forage species such as rose clover (Trifolium hirtum All.), subclover (T. subterraneum L.), and hardinggrass (Phalaris tuberosa L. var. stenoptera (Hack.) Hitch.). The greatest problem in the establishment of these species is the severe competition from the resident annual grasses and forbs. Heady (2) found the number of resident plants early in the growing season to vary from 20 to nearly 100 per square inch.

1/ Taeniatherum asperum (Simk.) Nevski by European authors.

METHODS AND MATERIALS

Spraying and seeding were done on November 2, 1962, about two weeks after the first fall rain. The newly germinated crop of medusahead was 1-2 inches high and covered with a heavy accumulation of medusahead litter (Approximately 4,000 lb/ac.). Paraquat was sprayed in eight-inch bands at 0.5 lb/ac cation per sprayed acre immediately ahead of the drill openers (22-inch spacing) during the seeding operation. A mix of equal parts hardinggrass and subclover was planted at 8 lb/ac, and single superphosphate banded beneath the seed at 200 lb/ac. Unsprayed plots were planted as checks.

Similar trials were conducted in seven locations in the fall of 1963, and four locations in 1964 with modifications in plot design. Various band widths were tested - narrow (5-8 in.), wide (9-12 in.), full spray coverage, and unsprayed checks. Also included as the main plot of the split plot design in 1963 were two fertilizer banding treatments, 16-20-0 at 100 lb/ac and single superphosphate at 100 lb/ac. Four replications were fenced and four left open to grazing at each location. If adequate grazing was not available plots were mowed to simulate grazing.

RESULTS AND DISCUSSION

Hardinggrass seedlings were mere threads of 2-3 leaves and 2-7 in. high in the unsprayed rows at the end of the first growing season as compared to robust plants about 12-in. high and 1-6 leafy tillers in the 8-in. weed-free band where paraquat was sprayed. As could be predicted, the plants in the sprayed strips lived through the dry summer, while most of those in the unsprayed checks died. Samples the following winter showed the checks to be 3% stocked with hardinggrass (one foot intercept of row) and the band sprayed area 76% stocked. Clover established well even in the checks, although the second year after seeding the clover stand was considerably better in the bands sprayed with paraquat.

Hardinggrass establishment was poor in the second years experiment because of a dry spring. Even seedings in fallowed fields were not successful. However, one location on the north coast near Geyserville was successful and the data are presented here (Table 1). Hardinggrass establishment was significantly improved by all paraquat bands. The grazed checks established a fair stand, while the fenced checks were a failure. Hardinggrass establishment was improved by the paraquat spraying treatment at 4 of the 7 locations. The remaining three were failures. Clover establishment was significantly increased by paraquat treatments in all seven locations when fenced, and five of the seven when left open to grazing (grazing usually gives adequate weed control for clover establishment and is the recommended practice). There were no differences between widths of bands sprayed - the narrow band was as effective as a wide band or full spray coverage. There was also no

Table 1. Hardinggrass and subclover establishment on band sprayed plots. Data are percent stocked (at least one plant per quadrat). Hardinggrass sampled with 12 inch row intercepts and subclover with 6 inch row intercepts.

Species	Subclover				Hardinggrass			
Sample Date*	April 22, 1964				January 12, 1965			
Grazing treatment	Grazed		Fenced		Grazed		Fenced	
Fertilizer treatment	0-20	16-20	0-20	16-20	0-20	16-20	0-20	16-20
Weed control treatment								
6 foot spray	81	70	87	88	75	73	29	33
11 inch band	80	76	86	84	60	60	19	25
5 1/2 inch band	74	78	84	76	58	79	12	18
Check - no spray	48	40	6	1	0	6	0	0
LSD .05	14		7		17		17	
LSD .01	21		11		25		24	

* Planted October 25, 1963

difference between fertilizers in the grazed trials, but the 16-20-0 did reduce the stand on two of the fenced trials due to the increased competition resulting from nitrogen fertilization.

In the third years trials clover establishment was aided by spraying in one of the four fenced trials, but not in any of the grazed trials. Clover stands were excellent in all of the grazed trials. Final measurements of the hardinggrass establishment will not be taken until next winter, but hardinggrass plants are large and vigorous in the paraquat treatments at this date, and dead in the non-sprayed check plots.

Among the most important points learned is that a heavy litter residue, always present with medusahead because of its unpalatable nature near maturity, is desirable. Heavy litter accumulations promoted complete germination of the weeds following the first rains, while in areas of light litter only part of the weeds germinated. Also paraquat remains on this litter and appears to be important in controlling new weeds as they intercept this litter. Weed control in minimum litter accumulations was only temporary, as more weeds germinated after subsequent rains.

The technique of spraying paraquat during the seeding operation has a great potential if succeeding trials continue to be this successful. The areas involved lie between the lands which can be safely and easily cultivated and range lands which are too steep or rocky to traverse with a crawler tractor. Also many tillable soils remain too soft for wet season grazing for several years after cultivation. Between these extremes are many thousands of acres which could be drilled using a modification of the rangeland drill developed by the U.S. Forest Service. The herbicide could be applied either as a separate operation or during the seeding by a sprayer mounted on the drill or tractor.

Improved inoculation technique for legumes.

Clover establishment has become far more reliable since using the seed pelleting technique described by Holland and Street (3). Each seed pellet contains a legume seed, the inoculant, and an adhesive (gum arabic), and a coating material (lime). The adhesive and coating material not only stick the inoculant to the seed, but influence the survival of the inoculant.

The following advantages are claimed for pelleting the seed.

1. "The pellet concentrates the inoculant around the germinating root. The chances of ineffective nodulation from resident soil bacteria are much reduced.

2. Sowing seed into dry soil. Adequate nodulation can be obtained even though 3 weeks elapse between sowing in dry soil and germination.

3. "Pre-inoculation. Sowing immediately after pelleting is the best practice. However, root-nodule bacteria survive in sufficient numbers to cause nodulation for 3 weeks after pelleting. With the standard inoculation process root-nodule bacteria survive only 24 hours.

4. "Aerial sowing. The mortality of root-nodule bacteria on the seed is high during and after descent. Pelleting should be useful as a means of reducing such losses."

Selective weed control in range seedings

Weedy annuals such as medusahead are not only a deterrent to the establishment of seeded forage plants, but may persist in abundance in established stands of the seeded species and reduce the quantity and quality of forage. Thus, we need a selective herbicide to remove the weedy annuals from new and established seedings.

Recent studies by the author have investigated the most promising selective herbicides for use in range seedings. 4-(2,4-DB) was shown to selectively remove annual broadleaves from clover seedings, while dalapon was demonstrated to have limited possibilities for removing annual grasses without damage to clover (4).

Paraquat applied under weed-free (cultivated) conditions affected neither herbage nor seed yield of rose or subclover (5). The addition of a surfactant (X-77 @ 0.05% vol./vol.) caused a reduction in yield of rose clover, but not of subclover. Varying the concentration of the surfactant had no significant effect.

In a companion study paraquat sprayed at 0.5 lb/ac removed weedy annual grasses such as medusahead, foxtail fescue (Festuca megalura Nutt.), and wild barleys (Hordeum sp.) from range seedings of rose clover and subclover with only temporary damage to the clovers. Applications were made during the period of slow growth in the winter.

The study reported below investigated the effects of paraquat and clipping not only on composition, but also quality and yield of an established hardinggrass-subclover pasture.

METHODS AND MATERIALS

Paraquat was applied at 0.5 lb/ac with and without a surfactant (X-77 @ 0.05% vol./vol.) on two dates, November 11, 1963, and February 19, 1964. These dates represent early and late in the cold winter period of minimum growth. The subclover had 3 trifoliate leaves at the first spray date and a vegetative rosette of many leaves on the second date. One-half of each plot, including the unsprayed check, was clipped at 2 in. 5 times during the growing season. Clipping was to simulate the recommended management practice of grazing to prevent the pasture from becoming grass dominant. Composition was measured by the step-point method (1) at the last clipping date. The experiment was a split plot design with 5 replications.

RESULTS AND DISCUSSION

All spraying, clipping, or combinations of spraying and clipping reduced the annual grass (from 66% annual grass on checks to an average of 2.3% on the treated areas). There was no difference between clipping alone, clipping plus spraying, or between dates of spraying on composition. Seeded species, including hardinggrass, were increased by all treatments (33% on the check compared to an average of 96.8% on treated areas).

Forage quality was generally increased by all treatments. Protein was 10.7%, 16.0%, 15.5%, and 17.7% for the check, clipping, early spray and late spray, respectively, at the last clipping.

Spraying at the early date delayed forage production until March, but subsequent growth (8,960 pounds oven dry/acre), nearly equalled total seasonal production on the check (9,270 pounds). Plots sprayed at the late date yielded significantly less than the check (8,330 pounds) apparently because the remaining growing season was too short for maximum production. There was no significant difference in yield between dates of spraying or the use of a surfactant. Also, clipping had no effect on total yield, a single clip yielded the same as the sum of 5 clippings.

Control of spread into uninfested range areas.

Two counties, Fresno and Madera, are conducting a medusahead eradication program. The weed is apparently a newcomer and the non-infested acreage is small. Spot treatment in the dough stage with weed oil is the recommended practice. Other herbicides would do equally well, but are not registered for pasture use.

Medusahead seed carryover in the soil.

The best of our control treatments are not 100% complete. There is always some medusahead the following year. Thus we suspect the seed is remaining viable in the soil for more than one season. Three hundred square feet of growing medusahead sods, about 2 inches thick, were transplanted to the Davis Farm in the late winter of 1961-1962. Medusahead plants growing from these sods were clipped carefully in the spring of 1962 to prevent formation of flowers and seeds. The sods were allowed to germinate and grow naturally the following winter and in the spring of 1963 produced an average of 7.5 medusahead seedheads per square foot. The spring of 1964 produced 0.08 seedheads per square foot, much less than the 185 per square foot measured on the area the sod came from, but still a source of re-infestation two years after a 100% control of seed production.

Management of medusahead ranges.

Burning to reduce the amount of medusahead in the composition has been a recommended practice for many years (7,8). However, in recent years medusahead burning has become popular just to remove the litter and make the new forage crop available to livestock. The best time for burning would be before the seeds have shattered in order that a maximum number of medusahead seeds would be destroyed. However burning in the early fall, even after germination will remove the objectionable litter without damaging the new forage crop.

REFERENCES

1. Evans, R.A., and R.M. Love. (1957) The step-point method of sampling - a practical tool in range research. Jour. of Range Mangt. 10: 208-212.

2. Heady, Harold F. (1956) Evaluation and measurement of the annual type. J. Range Mangt. 9, 25-27.

3. Holland, A.A. and J.E. Street. (1965) Seed pelleting as an aid to legume seed inoculation. In press as AXT Series. U.C. Agric. Ext. Service.

4. Kay, Burgess L. (1963) Effect of 4-(2,4-DB) and dalapon on three annual trifoliums. Weeds 11, 195-198.

5. Kay, Burgess L. (1964) Paraquat for selective control of range weeds. Weeds 12, 192-194.

6. Lusk, W.C., M.B. Jones, D.T. Torell, and C.M. McKell. (1961) Medusahead palatability. Jour. of Range Mangt. 14, 248-251.

7. Major, J., C.M. McKell, L.J. Berry. (1965) Improvement of medusahead-infested rangeland. Calif. Agr. Ext. Ser. Leaflet 123 Rev.

8. McKell, C.M., A.M. Wilson, B.L. Kay. (1962) Effective burning of rangelands infested with medusahead. Weeds 10, 125-131.

Discussion
by
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Fulcher: This has been an extremely interesting meeting and has provided some food for thought on range management problems. There should be more opportunities of this type to get away from our day to day work load and concentrate on the technical aspects of our profession.

After listening to the speakers discussing cheatgrass ranges having 2, 3, and 4 acres per AUM carrying capacities with average livestock gains of 1-1/2 pounds per day for seven months, I am sure many of you wonder why cheatgrass is considered a problem. You who are here from the southern areas of New Mexico, Arizona, and Utah probably wish you had such a problem.

A great amount of information has been presented. As would be expected, there appears to have been some conflict in the information from the various reports. However, in general, there was a great deal of agreement. I think it is now appropriate for us to try to evaluate what this information can provide as a guide toward improved management of our western range lands.

Mr. Sawyer, in his opening remarks, set a good theme for the meeting. He stated that we know the bad things about cheatgrass, so let's take the positive approach and determine if cheatgrass has any good points and what we can do in our management program to make the most effective use of this annual grass.

This portion of the program is a split assignment. Bill Mathews will discuss the significant points that have a bearing on the management of annual ranges. I would like to make a few comments on some of the Bureau of Land Management's policies on land resource management.

The Bureau is responsible for management of the land resource, and one of its major objectives is watershed protection and soil stability. Fortunately, good grazing management in most cases is good watershed management. Proper grazing use is not competitive with watershed protection; in some situations, it is a complementary use. However, the Bureau is responsible for multiple use management, and maximum production of forage for domestic livestock production is not the goal. We do hope to improve and maintain the public lands at a desired level of forage production in harmony with watershed protection and other resource uses. We expect livestock grazing to continue to be a major use of public lands, and the maintenance of stable livestock economies in public land states is one of our objectives.

Economic considerations are becoming increasingly important in our Bureau program. No longer can we justify conservation programs for the sake of conservation merely because we believe it is good. Congress and the Bureau of the Budget now demand benefit cost ratios on our projects and cost efficiency in the selection of alternative programs. User charges for the use of public land resources is being studied in view of the Administration's philosophy that users should pay a fair market value for services and products received.

Range administration policy in the Bureau is shifting to more intensive grazing management as the range adjudication program nears completion. The adjudication program has established stocking rates. Allotment plans are being revised or new ones developed, and changes in grazing systems are being initiated. Emphasis will be placed on allotment evaluation using actual use, utilization, and trend as factors to evaluate effectiveness of the management plans.

The Bureau is approaching a budget of $700,000 annually for contract research. For a small agency like the Bureau, this is a sizable amount of money. Careful scrutiny of both existing and proposed new research projects will be made to assure the most effective use of our research money to provide answers to our land management problems. The type of research needed by the Bureau is of necessity problem oriented.

Information from this meeting would indicate that the BLM's policy in the use of cheatgrass ranges needs to be reviewed. We must remember, however, that hindsight is always easier than foresight, and the policies developed were considered the best based on the information available at the time. Certainly the major benefit of this type of meeting is to show where mistakes have been made. Therefore, I think I will now turn the meeting over to Bill Mathews who will discuss some of the management considerations alluded to in the reports that have promise of making the most effective use of annual grasses.

Mathews: You research people are certainly to be complimented. You are providing a very vital service to the land management agencies. After listening for the past two days, I have developed certain management assumptions. I would like to throw these out for your consideration - test them out on you and see what you think of them. Perhaps we can reach some conclusion that will be of real value to the fellows out on the ground.

I like the way Max Lieurance put it this morning - he said that we are not concerned in managing for cheatgrass, but we are concerned in managing cheatgrass. This is perhaps one of the mistakes we have made in the past. We have asked ourselves, concerning a particular range, whether or not we are going to manage it as a cheatgrass range or whether we are going to manage it for a perennial range, and I think right there we got ourselves into a trap. If we had directed our

attentions instead to managing of the cheatgrass, some of the answers would have become self-evident. My impression from this discussion is that if we are going to manage cheatgrass range, then we should be concerned with harvesting the forage at the time when it will make the greatest contribution to our range area involved. If we are going to harvest the forage at the time it will contribute most, we won't be turning out April 1 as we have always thought was the time. Ordinarily we think of using the cheatgrass ranges first and then moving up, but in April cheatgrass doesn't contribute very much. So if we wait until mid-May, at about the time flowering begins, then like Jim Klemmedson states, I believe cheatgrass would be making the greatest contribution. He also indicated that this is when grazing use is the most damaging to cheatgrass, and therefore would tend to favor the perennials. So it would appear to me that if we use cheatgrass at a time when it will make the greatest contribution, the trend ought to be toward a perennial stand, and it will come about without our having to worry about it too much. Now, can we have some discussion on this point.

Question: One thing, Bill, it might be the ideal time to use it but it's such a short period there that you would have to have so many livestock for such a short time to get any type of use out of it. It seems it would be impractical to try to use it at just the most opportune time. Max's plan out here was to use crested wheatgrass first, which is a little different twist, and then at a later date move on to the cheatgrass ranges.

Statement: It is practically impossible to actually use cheatgrass at the most opportune time, especially when you have such tremendous variation from year to year in its growth.

Question: Isn't your comment a little contradictory to what we have already heard? We have been told that the later use favors cheatgrass itself.

Mathews: Yes, you are right, that is the position that Art Sawyer took. Later turnouts had increased cheatgrass. To my way of thinking, this conflicts with Jim's finding over at Saylor Creek.

Statement: Sawyer said this as an assumption from his observations over the past years, and he doesn't have any data to back it up.

Statement: It's just like this. Like burning or plowing - if you had a little there before, when you are through you've got a pure stand, and I think you get the same reaction if you keep cattle off in the spring - you get a lot of cheatgrass.

Question: When would you say would be the proper time to harvest the forage if you had full control over the situation?

Statement: I think we've got to have real flexibility in our management and attempt to take advantage of it when it's there. Cheatgrass just isn't there much before the first of May in this country.

Statement: It has been our observation here in the Vale district that cheatgrass contributes very little early, and most of the pressure is on the perennials until the cheat comes on, which is usually after the first of May, except in very exceptional years. By going onto the crested wheatgrass first, there is generally ample feed on the cheat areas in the normal year around the first of May. We just can't be married to any particular grazing system. Where we've gotten into trouble is where we have had to standardize our systems.

Statement: If you have a good cheat year, perhaps you could add a few temporary AUMs to get some additional use, like on the forest, most permittees have twice as many cattle as they have permits for, and they've got to take care of those livestock when they are off the forest anyway. Maybe they could defer some of their pastures and put these extra stock on the cheat areas, that way you could use it as a management tool.

Matthews: Are there any other comments?

Statement: I feel that these seedings are the key to flexibility in management of cheatgrass ranges. We could use them to help regulate the numbers on the native range.

Statement: Seedings are helpful but they are not necessary - we can still have areas which are native as turnout areas and these work very satisfactorily. The key is to get off while there is ample growing season left and allow them to grow up, and then have that old forage to go back on in the spring. This will, in a way, take the place of seedings. Late turnout may help cheatgrass, but it also helps the native perennials. The time to start rotating from cheat ranges is when the livestock begin to go from the cheat to the native perennials.

Matthews: When are your native perennials mature here?

Statement: It depends on the elevation, but they are beginning to get pretty mature right now in the higher country, especially this year when we had late rains. With a lot of rain in June, they probably won't mature until the middle of August.

Matthews: What period of time would you be on your crested wheat?

Statement: It will vary from the middle to the end of May.

Matthews: I think we have concluded that we are going to have cheatgrass to manage, and there are several primary problems involved - one is fire. I don't think there is any question that the cheatgrass does make a fire hazard. However, with improved control methods, that isn't the problem it used to be. Also, you will probably be able to devise degrees of grazing whereby we can control the fire hazard and still not injure the stand. The problem of flexibility has been mentioned several times; certainly in cheatgrass management we have to have flexibility. It may be advisable to provide some cushion in the cheatgrass area itself as to amount of stock that we can put in there. It may be desirable to stock those areas on the conservative side and have some cushion built into the total season-long management program. Also, it may be advisable, if you have extensive stands of cheatgrass, to get the ranchers to run only a portion of their stock - cows and calves - and hold the balance - perhaps yearlings - so that they have more flexibility in their ranching end of it. You want to use all avenues - you do not want to rely on one aspect. Also, in crested wheat management, you have to have management control. This is one of the primary problems of the Bureau in the past. We didn't have management control, therefore we have had to stock it at rates that were definitely on the conservative side in order to avoid excessive use of the perennial grasses. While with management control, you can put the cows where you want them and keep them there for the period of time you want them.

Fulcher: Sneva's research came up with a predictive model on precipitation. Can we take a look at the thing on, say the 15th of April, and come up with some idea of what our production is going to be?

Sneva: There is additional work going on in this field of prediction. Perhaps in another three or four years we will have some more

answers. Even if we could **predict**, there is still going to be considerable variability from year to year, I am sure of that.

Matthews: Management certainly is an effective tool for converting cheatgrass to perennials - also mechanical treatment holds a lot of promise. My conclusion was that through a deep furrow arrangement, our chances for success are pretty good. Some of the drilling that we have done in the past did not provide as much of a deep furrow situation as desirable. Where you are going to do seeding in cheatgrass stands, you ought to take a good look at the drills and see if they are doing the job. If not, better improvise some means of modifying them by adding weights or changing the pads on the disc, or even using an entirely different furrow opener. It appears to me that the double disc arrangement as a furrow opener should do a good job.

Statement: One of the things we have done is that we have plowed brush areas and all we have done is stimulate the cheatgrass. What we should have done was sprayed and drilled with a deep furrow drill. We found this was a mistake, plowing these areas - all we got was more cheatgrass.

Matthews: I think you are right. We used to think that plowing would do a lot for us in relieving the competition, but it did just the reverse. We have also found that chemical control offers real promise. At first it appeared that the cost of the effective agents were out of reason, but Bud Kay's last presentation indicates that it is getting down to the point where we can afford it. We also found that they have a lot of variability in their effectiveness from one locality to another, so certainly before you proceed with any sizeable chemical control program, you want to have some trial work done ahead of time to make sure that your methods stand a fair chance of meeting the objective.

A point on the use of fungicides is very important. It is something that I had never even heard of before today. With the low cost involved, at least wherever planting in sites that do support cheatgrass stands, that it would be good insurance to have the seed treated first, so when you let your invitations to bid you can take that into account.

Question: Would you have this made part of the bid?

Matthews: Yes, I would do it this way.

We have also heard of the use of fertilizer for converting cheatgrass stands to a more desirable type of vegetation. My impression is at the moment this does not have a practical application on our lands. Is my assumption correct?

Statement: At the Butte, the application of nitrogen at 30, 60 and 90 pounds has had a tendency to convert the range to cheatgrass. It certainly has increased the annuals. Fescue had a tendency to go out, Sitanium had a tendency to increase slightly, cheatgrass started to come in on crested wheat at Squaw Butte. At Squaw Butte we could, on crested wheat, get good response at about 30 pounds of N. We can't make the economics of the thing pay off. You can buy a ton of hay for about $20, I think we can get our grass yields cheaper in other manners.

Matthews: One other thing I would like to mention - that is, using old experience, we have assumed intermediate didn't have a place in seedings on low rainfall ranges.

Statement: It is cheaper to get an increase in bluebunch wheatgrass by removing competition than it is by fertilizing. We increased production of wheatgrass an initial 30% after we had taken out the competition and applied 80 pounds of fertilizer. This was under protection, without grazing.

Statement: We got essentially the same on a study with intermediate wheat where we applied fertilizer we lost the intermediate wheatgrass.

Fulcher: Cook has done some work where he indicates fertilizer may have some value in animal distribution.

Statement: Down south, there was a report published about the use of fertilizer for deferred rotation grazing.

Statement: We've done the same on the Deschutes to protect pine plantations.

Fulcher: One comment on Medusa before I sit down - it occurred to me that where we do have a threat of invasion by Medusa,

we make a concerted effort to get our ranges to the point where they are supporting a good stand of perennial grasses as rapidly as possible. After the Medusahead has invaded then we have a real problem.

Fulcher: Where we have a lot of Medusa, we'd better graze hell out of it rather than try to cut back on our stocking rate. I didn't hear anything today that would contradict that approach, particularly on those areas where we have it so thick now that everything is suppressed.

Should Seed be Treated Prior to Planting?

During the course of this symposium, several questions were asked about treatment of grass seed to control the pathogen responsible for seed rot and root rot of range grasses. In 1964, the Oregon State Office requested from A. T. Bleak, Research Range Conservationist, Crops Research Laboratory at Utah State University, information regarding the pathogen Podosporiella verticillata. The following is the verbatim summary taken from the reprint covering most of Bleak and Kreitlow's studies with this fungus. Also, portions of an informative letter received from Mr. Bleak in December of last year.

Summary

"Seeds of important range grasses and cereals in Utah are attacked by a soil-borne fungus (Podosporiella verticillata) which reduces seedling emergence and vigor. Species of Gramineae found infected to date include: crested wheatgrass (Agropyron desertorum), intermediate wheatgrass (A. intermedium), slender wheatgrass (A. trachycaulum), fairway wheatgrass (A. cristatum), smooth bromegrass (Bromus inermis), cheat (B. tectorum), mountain bromegrass (B. marginatus), barley (Hordeum vulgare), rye (Secale cereale), and wheat (Triticum aestivum). Incidence of infestion varied with location and season. Most infection occurred at lower elevations on sagebrush sites. Less infection occurred on mountain brush sites and none on aspen-fir sites. Percentage of seed infection decreased with later fall planting. Appreciable seed infection in most grass species tested usually could be found within 2 months after planting. Seed infection occurred at planting depths up to 24 in. When seeds of Gramineae were sown in infested soil in the field and in artificially infested sand under controlled environment in a growth room, smooth brome was most heavily infected. Crested, fairway and intermediate wheatgrasses and wheat were moderately infected. Mountain brome was slightly infected and slender wheat and barley were least infected. No infection was observed on seeds of wild oat (Avena fatua) or Rambler alfalfa (Medicago sativa)."

Letter from Mr. Bleak

"We have done quite a lot of work with the fungus Podosporiella. This widespread organism has been found to be especially abundant in the sagebrush grass type where cheatgrass is present. Cheatgrass usually

favors a high buildup of this fungus in the soil and litter.

"Work just completed indicates that seed treatment with Captan 75 (Orthocide 75) will give good control of this fungus when applied at a rate of 12 oz. per 100 lbs. of grass seed. The manufacturers of this fungicide recommend a rate of 8 oz. per 100 lbs. of grass seed, but some infected seeds have been found on many fall plantings. However, the 8 oz. rate should give adequate control for plantings made in the spring, since the seeds usually germinate soon after planting.

"Application of Captan 75 as a slurry has given slightly better control than when applied as a dry powder.

"Arasan 75 at a rate of 6 oz. per 100 lbs. of seed has been comparable to Captan 75 at the 8 oz. rate, but it may be too expensive for practical purposes. Both Captan 75 and Arasan 75 gave better control than Semesan. Also, seed treated with Semesan should not be stored after seed treatment."

Summary Remarks of Cheatgrass Symposium
by
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Technical aspects of the material presented by each of the researchers is well covered in the abstracts and notes which they have included in these proceedings. These comments are limited to an evaluation of the symposium and suggestions for improving something that in my opinion is already very good.

At the beginning of the conference Dr. Poulton gave us a charge that was worthwhile and should have been kept foremost in the minds of all the participants throughout the conference. Dr. Poulton charged us with the responsibility to present ideas, discuss ideas, to pool our thinking, to table and resolve our differences, and to use knowledge and information acquired to accomplish better resource management in Oregon and throughout the west.

Did we meet this challenge?

Throughout the course of the symposium, I had occasion to question whether we attending the symposium had fully accepted the charge which Dr. Poulton gave us. Some possible questions concerning the success of the symposium and some suggestions for consideration are as follows:

1. Was the attendance at the symposium too large?

2. Did the large number of people attending the symposium inhibit or preclude the amount of discussion which would have been desirable in brainstorming some of the ideas which were presented?

3. Did we even begin to exploit fully some of the ideas that were presented to us?

4. Was the amount of discussion between researchers and participants and among participants satisfactory?

5. Did the discussion tend to be among researchers presenting papers in attendance at the conference rather than between researchers and land managers?

6. Was the information presented by the researchers too technical?

7. Was there too much data presented with not enough interpretation?

8. Was there too little attempt to convert research information into answers to practical land management problems?

9. What should be the responsibility of the researchers in trying to make this conversion?

10. Did the symposium give new direction to researchers in attendance in planning research projects which will be of maximum value to the range resource in the west in ensuing years.

11. How can we improve the symposium.

   a. It would appear that it might be wise to break up into smaller discussion groups at the conference. This would provide an opportunity to do a better job of brainstorming some of the ideas that are presented and would present an opportunity for more participation by individuals attending the symposium.

      Well led discussion groups often result in bringing a considerable amount of attention and thinking to bear on specific problems. I would suggest a survey sheet be developed and sent to each of those attending the symposium asking for their candid critique and suggestions concerning the symposium and how to improve upon it.

The symposium was good and provided all those in attendance with a multitude of new ideas which should be of value to them in the work of resource management. However, each of us should accept the idea that we must be continuously trying to make even the best better.